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Man, Physical Resources, and Economic Organization*

HAROLD F. BREIMYER

Formal economics has centered on the combination of resources. Contemporary events force concern for forms of economic organization, inquiry into which must put the human role uppermost. A taxonomy of economic organization contains three systems of production and three of control. The Enlightenment brought freedom of contract as a control system, which fits well with proprietary production in farming but clashes with industrial nonfarm production. The nonfarm economy faces institutional reform, while farming must choose its production-control pattern. Examination of alternate production and control systems can aid in organizational choice.

WITHIN recent centuries Western man found himself favored by a convergence of three transcendent historical forces that promised to fulfill his oldest dreams. Almost in unison came the dramatic scientific and technological breakthroughs that engineered the industrial revolution; the new moral-religious code that charged individual man with earning his temporal and eternal salvation; and the discovery of virgin continents that offered opportunity for aggrandizement without pirating one's fellows.[1] The outcome in terms of material advance has been rhapsodized often.

The three historical forces encompass three basic elements that shape man's destiny: the nature of man himself, the physical resources at his disposal, and the kind of socio-political-economic organization employed for production, distribution, and civility. That the three are interlocked is a hackneyed truism.

Also axiomatic is that the discipline of economics has uneven facility to deal with them. Formal economic thought has long concentrated on the combination of resources. The organizational system has received spasmodic attention, once expressed in academic debate about comparative economic systems but recently emerging into social criticism. Man's attributes are usually shunted aside as either immutable or irrelevant.

Attention cannot continue to be centered so narrowly. Contemporary events suggest as much. Rampant exploitation of physical resources is being rebuked, as alarms are sounded over damage to environment and incipient depletion of mineral energy. These issues have their own savants. Also trumpeted are institutional changes such as centralization of economic power in the conglomerate corporation or the corporate State, and persistence of economic forces that escape the internal economics of the firm ("externalities"). Socioeconomic criticism now extends to skepticism about the adequacy of our macroeconomic policy measures and protest against boredom-dehumanization consequences of large-scale organization.[2]

Agriculture, a primary industry, is much involved. It is critically sensitive to many resource issues. It is equally sensitive to organizational questions, often posed as whether the traditional organizational form with its distinctive place for the human element can or should survive. If "institutional innovation" was once admonished as an intellectual exercise, it has become a mandate (cf. Shaffer [22]).

How shall organizational matters be addressed by the economist as such or as social scientist, of agricultural or other discipline? More than a century has passed since economics blossomed out of political economy. Insecurity is manifest, for lapsed skills are not readily recovered. Yet a disciplinary eclipse, like a solar eclipse, is transitory. This article, admittedly more introductory than conclusive, is intended as an aid to help economists recapture sidelined talents. The following three theses underlie this attempt:

(1) Although the final concern of this paper will be the economic organization of agriculture (principally the farming part), this is properly addressed in the context of organization of the total economy.

---

* I am grateful to Marshall Harris, James Rhodes, James Shaffer, James McKinsey, Paul Nelson, Jr., and two anonymous reviewers for critical reading of an earlier draft. The usual assurance of nonculpability applies.

[1] Except American Indians, Africans, Maoris, or Australian Aborigines, as a perceptive reviewer pointed out.

[2] Cf., respectively, the *Saturday Review* Symposium, "Does Economics Ignore You?" [23] and the April 24, 1972 issue of *Newsweek* [24].

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(2) To deal with the subject requires bringing various disciplines to bear. The call to do so has become liturgy. Glenn Johnson's phrasing is apt: " . . . the problems and issues before our society . . . *are so complex that the demands they place upon our disciplinary concepts, information, and quantitative techniques exceed the present capacities of our disciplines*" [9, p. 731].

(3) Although technical studies of the combination of resources may properly treat human and physical resources as equivalents, an analysis of the organization of the economy must give priority to the human being.

The Human Equation

Early classicists briefly considered the role of man. As every apprentice knows, *The Wealth of Nations* opens with testimony to the productive magic of division of labor in pin making. Yet Adam Smith as a professor of moral philosophy was concerned for, in Max Lerner's words, "the expression of forces . . . working . . . to fashion . . . *homo oeconomicus*, or the economic man of the modern world" [12, p. v]. Smith noted the drearier aspects of specialization; according to West he "was disturbed that with the progressive routinization of daily life and with the growing monotony associated with repetitive factory work, men themselves stagnated and 'stupidified.' " But Smith advocated little more than that each person, in West's phrasing, should seek happiness in the company of his fellows and in an "environment wherein the individual is absorbed in the pursuit of new excellence, new knowledge and new invention (or to use Smith's terms: Wonder, Surprise, and Admiration)" [25, pp. 56, 57]. Thereupon the subject was dismissed, and throughout classical and neoclassical economics the unwritten theme is that the splendor of productivity either vitiates or compensates industrialism's drudgeries.

Recently, owing in part to social criticism, the primacy of the human element in economic organization has won more recognition. Campbell, for example, insists that economic policy for our time, made outside the "chaos . . . between the various sciences," "must be based on an understanding of man's nature. What is it that constitutes man's excellence? Where does he stand in the total scheme of things?" [4, p. 20].

In relation to the central question of this essay, the above asks what configuration of incentives and rewards, sanctions, and ideology is conducive to responsible individual performance in various forms of economic organization. Forms considered herein range from individual proprietorships to the giant corporation. Omitted are self-sufficiency at one extreme and central-government control at the other.

Three Production and Three Control Systems

A taxonomy of systems of organization is basic to inquiry into economic organization. Focussed on the place of the individual in the system, the taxonomy that follows is dual: one set of categories relates to production, the other to control—the combination of sanctions and rewards (see chart).

Taxonomy of Economic Organization

Production System	Control System (sanctions-reward)[a]		
	Bargained commodity exchange	Status	Contract
Craft/agrarian Isolated individual—singular product	medieval craftsmen, yeoman farmers, selling in open market	some indenture type arrangements	contractual integration of U. S. family farmer[b]
Manorial Individual-in-group—singular product		all group organized conventional systems, as tribe, medieval manor, plantation	business partnerships, some small corporate enterprises
Industrial Individual-in-group—jointly produced product		the so-called grants (transfer payment) portion of the economy	most modern corporations

[a] The terms are illustrative, not definitive.

[b] So classified assuming freedom of opportunity in negotiating. Any tying or satellite relationship throws contracting into the status category.

Systems of production

The three production systems as defined in terms of the role of the individual are short-titled craft/agrarian, manorial, and industrial. The first is the simplest case, that of the isolated individual producer and marketer. Best examples are the independent craftsman, more common in medieval times, and the yeoman farmer. They truly turn out and market a product of their own.

Though the sturdy craftsman or yeoman is often glorified, he has been rare. Throughout history most human beings have pursued their livelihood in a group setting. The two classes of group organization, manorial and industrial, differ sharply. The manorial involves occupational specialization performed within an overall supporting unit. Historically that unit has been the family, tribe, Greek or Roman "household," medieval manor, or plantation. The specialization was far short of the specialization of process that Adam Smith advocated. Each person retained a comparatively distinctive role; he turned out an identifiable product or service; his handiwork was visible, to others and to himself.

In the modern industrial system specialization is carried so far that the individual is no longer identified with a discrete product. He only contributes to joint output. Individual identification is lost. This is true not only of the factory assembly line, a too-common and therefore misleading image, but of much corporate and government bureaucracy.

This feature, widely noted in contemporary literature, has the psychological aspect of lost identity and the economic aspect of nonmeasurable value of product. Frank Roosevelt remarks that "a great many workers have lost any sense of control over what they are doing . . . " [20, p. 126]. Glenn Seaborg writes of the "separation of man and product" [21, p.22]. Nell comments on both aspects of the breach and ventures statistical estimates. After noting how often is "connection with output . . . indirect, uncertain, and hard to estimate physically," he writes that 15 percent of all the working force identifies with product but only three or four percent does so in a way subject to estimation [15, p. 444].

Systems of control

Historically control systems have relied variously on economic incentives and on political and social sanctions. Without undue simplification the basic systems can be classed as bargained commodity exchange, status, and contract. The latter two terms are borrowed from sociology and political science.[3]

Bargained commodity exchange is virtually self-defining. As used here the term applies to the solitary individual's offering his product for negotiated barter or sale.

Status and contract systems arise in group organization. The status system is conventional, with the individual's lot cast for him both as to duties assigned and rewards received. The status system has predominated in the world's history. It has taken a hundred forms, among them the oppression of slavery, the less onerous feudalism, and the democratic communes or colonies as advocated by Robert Owen and established in several places in 19th century America.

The contract basis for economic organization is modern. This legacy of the Enlightenment—or what Polanyi calls the Great Transformation—freed individual man to be the agent of his own destiny. It removed the shackles of status and enfranchised him as never before. A contract system, by its implicit definition, permits each individual to seek out his best opportunity, free of any preemptive control or restraint.

To ask whether the promises of the Enlightenment have been kept and what would be necessary to keep them only rephrases the initial questions of this paper. Since a control system exists interdependently with a production system, further analysis must involve various combinations of production and control.

Production and Control Systems in Combination

In the past production and control systems have tended to align. Bargained commodity exchange as defined here was primarily associated with the craftsman/agrarian system of production (see chart). Likewise, to a large degree the status system of control accompanied manorial production.

The contract system, though having ancient antecedents, is usually associated with industrial production because it achieved prominence alongside the new industrialism. But an easy *post hoc, ergo propter hoc* judgment must be avoided. It is not necessary that industrial production be accompanied by a contract system (the Soviets have taught us that!). Furthermore, the contract system of control may not be as harmonious with industrial production as might be inferred from their historic coincidence. The combination achieved to date is partial, imperfect, tenuous, in danger of reverting, and in the eyes of its critics, in need of reformation.

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[3] See Campbell [4] for one source.

Bargained exchange-craft/agrarian production

A bargained exchange system is normally associated with the craft/agrarian production system wherein the individual produces and markets his own product. This is the pristine concept, one that scholars hold to almost as a reflex action. The bargained exchange concept is most applicable to the workman who alone produces a shirt or a hog and offers to sell it (directly or through a market) to another solitary individual who produces a chair or a dozen eggs.

It is no happenstance that textbook examples of exchange are often drawn from farm products, where the image still fits fairly well. The organizational issue in agriculture is in fact capsuled in whether that important sector will continue to be one of proprietary production and exchange or will change radically its production system or control system or both.

Bargained commodity exchange is of course the simplest system to implement. Income from a person's own effort becomes his incentive for more effort. The accompanying ideology involves the work belief or ethic John Brewster wrote about [13, p. 60] and the protestant doctrine of reward proportionate to performance. Its sociopolitical system calls primarily for physical protection against brigands and the legal institutions of an open market. Needless to say, early theories of value were projected against such an exchange market economy, which accommodated a labor theory of value.

A principal weakness of individually bargained exchange is the uncharitable condemning of each person to live with his deficiencies. This is brutal to the handicapped, and thus advocacy of such an economy has been tempered with admonitions of Christian charity. An essential feature, pregnant with turmoil, is that each person must have access to the wherewithal for his personal enterprise—hence early systems of apprentice training and public schooling that could provide craft skills; and hence the excitement over access to raw continents that could provide every man with land to till and stuff to work.

Bargained exchange of individually produced commodities has not prevailed often in history. Most exchange has been carried on between groups—the tribe, the plantation, the factory, and the commercial firm. To endow group exchange with all the attributes of individual exchange, though tempting, can raise troubling questions.[4,5]

Status control-manorial production

The status system was preindustrial and therefore associated mainly with manorial production. It shelters and controls the individual in a group setting in which he retains considerable identity in his employment but limited rights of self-determination. The socioeconomic mucilage presumably consists of varied mixtures of reward and compulsion. In less advanced systems the individual's share of community product is decreed. In the more advanced it bears some relation to productiveness and in doing so introduces a distinction between proportional and residual sharing, antecedent of contested issues in reward systems under contract. The feudal serf may have given the lord only a fraction of his harvest or else a fixed quantity that left him with the remainder. Some element of compulsion seldom is absent.

Companion to such a system is a concept of justice in the sense of fairness in dispensation. This focus helps explain the religions that grew under status systems; many of these religions are currently struggling to convert from a status to a contract milieu. Under status arrangements religion alternately inspires to building a more just system here on earth and promises to compensate in the after-life for lifetime injustice. But the justice that is such a watchword is to be applied *within* the system; status-oriented religion seldom challenges the system itself or its Establishment. It follows that religion conduces to mutual support within the group. As Frank H. Knight writes, "Social-moral motivation . . . has a quality properly called religious . . . there is probably no group life without real 'devotion,' in a religious sense, of the members of the group . . . " [10, p. 321].

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[4] Papandreou asserts that "the capitalist economy of today is *not* in fact a market economy . . ." [17, p. 5].

[5] Reminder: This article is concerned only with the *individual* and the organization. It does not consider systems of interaction among organizations, for which a new nomenclature would be needed.

Contract control-industrial production

The Enlightenment that ushered in the contract concept of social organization was indeed momentous. However, it probably was not conceived of in terms of an industrial system of production. As noted above, the religious environment of the Enlightenment was conducive to individual enterprise and bargained exchange, and the entire age has evoked an image of buccaneers and pioneers rather than conglomerate industries.

Early classical economists latched onto the liberalism of the contract system and applied it to nascent industry. But they visualized small industry, not large. Even today the contract system is not applied to large industry exclusively. A farmer, for example, freely commits his services contractually at specified compensation. (The system does not apply to preharvest contractual sale.) Contractual relationships occur in business partnerships and small corporate businesses that retain a loose, preindustrial structure (see chart).

Nevertheless, the preponderant application is to large-scale corporate enterprise. The industrial-contractual combination not only receives the most emphasis, but also presents one important model to which agriculture could convert in the future (usually called "corporate farming"). Hence it merits careful study.

Like any system of social organization, the contract system has its companion concepts of justice, religion, incentives, and rewards, and its own requirements for institutional support.

Even as the bargained exchange system rests on each person's having access to land or other resources, so must a contract system in an industrial setting assure opportunity for employment. Justice, concerned under the status system with paternalistically dispensed equity, now is directed at nonforeclosing of any person's options—or, in an even more enlightened view, of guaranteeing that options exist. Monopolizing becomes a criminal act. In American history when the growing industrial structure violated the no-monopoly tenet, central government tried to respond. First it outlawed trusts; then, despairing, it turned to the promises of the Employment Act of 1946. Now it is considering such drastic action as guaranteed employment or the anesthesia of income maintenance.

Without disputing good intent or some achievement, the disaffections of our day suggest that steps taken thus far are not entirely effectual. Perhaps more wisdom awaits. But the suspicion grows of an intrinsic incompatibility between the lofty goals of contract relations and the nature of an industrial system of production. Indeed, a contract-industrial combination is heroic. Upon a production system that is intricately organized and must run like clockwork is imposed a control system that seeks to maximize the freedom of opportunity for the individual human being.

A contract system would have suited preindustrial circumstances better. In a manorial setting where the individual has a separate role, it is not hard to conceive of granting him broader rights of self-determination and reward commensurate with performance.

By definition the contract system eliminates compulsion, leaving reward and religion.

In an industrial setting, however, a convincing combination of incentives and rewards is hard to come by. The grand paradox is that sachems of business and of churches promulgate the reward-according-to-performance ethic of the Reformation. But how can it be applied where individual performance blends incognito into mass output? For a reward equation, economists resourcefully adapt the technique of marginal analysis, itself derived via the neoclassicists from an earlier agrarian economy wherein marginal physical inputs were added to a fixed land base to get a discrete and discernible marginal yield. Alas, marginality (as a basis for return to factors) conforms better to a manorial production system than to the industrial system. Modern industrialism dooms the technique.

It is doomed conceptually and operationally. How can a person be rewarded objectively for unidentifiable output? As Nell insists, "Marginal productivity applies only where labor inputs of uniform quality are directly connected with a physical product . . . " [15, p. 444].

The default of a satisfactory calculus of compensation is made worse by carrying caste features of the manorial system forward to the industrial age. In today's industry the tendency is for each person to contribute only one factor of production; even corporate ownership and management are being separated. As a consequence, possessors of each factor tend to gravitate into social classes, each of which has its niche in the hierarchy of prerogatives and of claims upon income.

Therein lies a meaningful distinction; farming, where each operator combines three or four factors in himself, forestalls social-class and income-distribution contests to some degree.

Operationally, the technique of marginality is doomed through active agents, namely, labor leaders. Although the specialization that marks our system relegates the individual to inconspicuousness, his role, normally shared with a few or many others, remains vitally essential. The invitation to ally with counterparts is irresistible, the potential gain great. There follows a new kind of marginality, one of monopoly derived from specialized competency. When other role-performers get into the act, the valuation system deteriorates into monopolies in contention; this helps to account, incidentally, for inflation amid idled resources.[6]

Policies—in Place and in Prospect

Analysis is prologue to policy. Among broad policy directions, three are readily set forth. The first is to arrest or reverse the industrial production system itself. The second is to revert toward a status system of control. The third is to seek acceptable modifications in the industrial-contractual system, for example those of industrial democracy.

Decentralizing or rehumanizing industry

Most visible of proposals are to break up the largest corporations, to decentralize both business and government into new territories of regional development, and to deter or even prohibit further take-over of small business by big business. These are familiar and need no review. A case can easily be made for keeping business size within bounds.

More inventive is a broad category of efforts covering a gamut from making the individual's work more meaningful to promoting a quasi-religious attachment of the individual to his sheltering employer. Regarding the first, *Newsweek* has reported that "Ford Motor . . . is experimenting with a 'team' approach to building some auto components with workers moving along the line"; Chrysler has been bolder: "Workers in one plant were allowed to run their own department while the foreman was on vacation; at another location workers themselves test-drove cars they had built" [24, p. 65].

In the middle ground are restless probings within academic circles regarding the role of management. Long ago economic thinkers named management a factor of production. This is a logical contradiction, for it equates land, labor, and capital to a factor that manipulates those three.[7] Semantic quibbling aside, managing the combination of resources has been emphasized. Only recently have ideas on management been directed to motivating human beings. This new direction has come mainly from outside economics in a field now sometimes elevated to a discipline, appropriately called Management.

Most exciting, however, are the strategems adopted within the business community to inculcate an *esprit de corps*, a sense of organic unity, within each organization. Boulding calls it seeking "an identification of the purpose of the individual himself with that of the organization" [1, p. xxxiii]. This implies a status system, and reminds of a tribal chieftain's exhortation to loyalty. Other devices are more prosaic. In a perceptive analysis Oberg [16] begins from the familiar ground that "work, for large numbers of employees, is not a rewarding experience." He says that each person plagued by anonymity of product needs "to find immortality of accomplishment if not of person." Further, "from an organizational point of view, moral commitment and faith in the organizations' goals and leaders are an almost unmixed blessing." And as though to elaborate on the analysis presented in this paper, Oberg refines the idea of contract to include not only the "calculative-utilitarian" contract, which is standard to most business organizations, but also the "moral-normative," "exemplified by churches, colleges, and ideological political organizations." Oberg questions whether business can adapt and adopt the latter [16, pp. 20, 24, 19].

Reversion toward status

Admonitions to organization loyalty, just noted, have a status cast, but a clearer instance of moving back toward a status system is the emerging so-called grants economy. This is characterized by transfer payments that are not based on individual performance. Social Security (OASI) benefits were originally insurance, which is contract, yet mandatory, which is a status feature. As the insurance features fade it is more exclusively status. It may be supposed that highly mechanistic formulas for compensation, such as public school teachers' years-of-service plus degree held, resemble status about as much as contract. In agriculture various programs have a status touch, e.g., compensatory payments for wool and mohair. Income maintenance as variously proposed would carry the principle much further.

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[6] The sharing of role that induces coalition for defensive or aggressive purpose, joining fellows in a craft or occupational function, is essentially horizontal. Horizontal aggregations then clash with vertically structured power units of the industrial firm or the state. It is a biaxial confrontation. New tendencies to horizontal unity jeopardize various other vertical alignments, even one such as the family; and they extend to many class- or caste-oriented associations. Junior high pupils now organize for protest!

[7] The factors are a logical monstrosity. Where did they come from? Capital is in no sense basic and is an ambiguous concept, as Joan Robinson devastatingly observes [19]. Better qualified for inclusion is governance. If capital, defined as physical resources converted to reproducibility, is to remain, why not add education?

Contemporary religion is caught between the two systems. When its conservative wing applies the protestant ethic to a contract-industrial system, social critics charge it with complicity in the distresses of our day. Meanwhile church attendance declines, and the two more vibrant trends resemble status more than contract. One trend is toward a fundamentalism that reminds of early Christians' temporal fatalism and eternal faith; the other is toward a trust in secular amelioratives such as public welfare programs.[8,9] Most inventive have been not the democracies but the totalitarian states that invoke Caesar-worship.

Institutional innovation

Institutional innovation that would revitalize is more dramatic. Only a few of the many proposals can be mentioned. Probably the starting point is to recognize the modern business firm for what it is—in Boulding's words, "an essentially collectivist type of enterprise" [1, p. 35]. John Fischer, redoubtable editorializer of *Harper's* magazine, quotes with tentative approval the notions of Robert Dahl (in *After the Revolution: Authority in a Good Society* [6]) that "the system of 'self-management' developed in Yugoslavia might be worth considering for adaptation here. Workers' councils, mainly elected by employees, have a considerable voice in the management of most enterprises, from factories to hospitals and the postal service" [7, p. 18]. Participants in a conference staged by the Center for Democratic Institutions discussed the idea of self-management, that is, "participational democracy in the work place, calling for direct involvement of the workers at all levels of decision-making" [5, p. 3].

Implicit in such a reversal of trends would be a recasting of the system for distributing the proceeds from common enterprise. Profit-sharing would be *sine qua non.* Index-linked loans and a host of other revisions in the established way of doing things would likely follow.[10]

The role of civil government must now be examined. Often the prescription is to use the democratic processes of the nation-state to bring giant business to heel. Apparently Galbraith holds something of this philosophy. There is no denying the burden that government carries in the modern industrial-contractual system. Much is to be said for improving the capacity of government to perform well; a tradition of *laisser-faire* has not led to sophisticated inquiry into the arts of exercise of governance. But the nation-state only aggregates further, only obscures the individual more. A preferred course must be to reform private organization.

Agriculture in a Contract Economy

To the organizational deficiencies revealed in our generation the farming sector is doubly sensitive. Even where individual exchange still prevails, the farmer is affected by the make-up of the commercial world from which he buys his supplies, to which he sells his product, and in which his sons and daughters—and possibly he himself—may seek employment.

Nonetheless, a focus more appropriate to this inquiry is the organizational system that farming itself will take. On the one hand, farming is not well suited to the industrial system of production, an observation Brewster often made. In this sector of the economy the production system facilitates retaining the identity of the individual and his work. Only the "factories" in eggs, broilers, and large cattle feedlots are major exceptions. Furthermore, most farming is still organized on an individual basis with the market exchange system predominating. Estimates are that around 80 percent of all farm products are produced by market proprietorships. Another 10 to 15 percent are contractually produced. About 5 to 7 percent are produced under industrial-corporation farming. The trend, however, is toward expanding the

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[8] The late Reinhold Niebuhr was an articulate and altogether admirable advocate.

[9] On the other hand, the churches' fight against discrimination is in the best tradition of the Enlightenment and a contract society.

[10] Cf. Prell [18].

latter two at the expense of proprietary production for the market.[11]

A side effect of new attention to organization of the commercial-industrial portion of the economy is to legitimize inquiry into the organization of farming. When the model of commerce and industry was still being eulogized, organizational issues in farming won little audience.

Avoidance of organizational drift

The main moral from the preceding argument may be to disqualify contractual industrialism as an acceptable model for the agriculture of the future. If it is running into trouble and generating institutional mutation where it has long been established, how can it be upheld as a desirable model for agriculture?

Foremost may be the question whether institutional innovation can be achieved in farming. Worst of all policies would be to "let nature take its course." In contrast any ritualistic defense of the status quo in farming would be inexcusable and probably futile. Historically the rural sector has been both van and rear in institutional change [2]. It could be in the van once again.

Choice among basic systems

To frame a farming policy, one or more basic systems must be chosen. The categories in the chart on page 2 make a good starting point. To what extent is individual proprietorship to be elected? Where that choice exists, is the farmer to buy and sell through a market? If so, some quick shoring up of present markets will be necessary. This would likely extend to underwriting access to land, credit, and technical knowledge. Laws for pollution control, tax policy, and a host of other regulatory measures must be designed to accommodate a market proprietorship farming. This is not idle rhetoric! An exchange system will not work if one part of the community is permitted aggressively to dispossess another, irrespective of how innocent the acquisitiveness.

If the farmer retains his "craft/agrarian" production system but moves into a contractual system of control (contractual integration), protection of his contractual integrity will be required. How can drift into status-system repression be forestalled?

Another set of possibilities comes under the heading of a manorial system of production. Included are partnerships among operating farmers, still fairly rare, and forms of cooperative action in which the farmer operates his own business but relies on his cooperative for a great many off-farm services including prenegotiation of contracts for obtaining supplies and marketing product. Indeed, the North Central Public Policy Education Committee (Extension) includes full-contract cooperatives among its list of major organizational systems available to the farming of the future [11]. However, such an organizational system would go far beyond present Capper-Volstead cooperatives; it could have a bargaining aspect to it.[12] More than that, its internal government would have features resembling the Yugoslav experiments mentioned above; and it would retain the label of a "contractual" control system only so long as that internal democracy functioned. If democracy lapsed, the cooperative would shift into the "status" category.

Design for the community

The analysis presented here is not well suited for considering community development. If, however, the inquiry were broadened to include the rural community, opportunities for institutional innovation would be legion. Some halting progress is already being made, as in forming regional planning units endowed with a measure of proficiency and power. Dreams of preplanned communities, complete with industry, with educational, cultural, medical and religious facilities, and with a viable farming component, can be given embodiment if only the will is there.

The Call for Institutional Innovation

Man, pursuing his relentless trajectory through time, must design his organizational system to fit his highest aspirations. His analytical eye must take into account alternate systems both of production and of control, and the former dare not dominate the latter without a reckoning of the consequences.

Modifications must be made in the industrial-contractual system that in mixed, impure form now tends to dominate. No longer can limitless resources of a New World be exploited under a system in which remaining shreds of the protestant work ethic are counted on to neutralize the disspiriting effect of mass organization that dwarfs the individual and hides his handiwork. Nor can the algorithm of reward regard man as marginally dispensable instead of intrinsically essential.

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[11] Estimates of the author. Contractual production is defined as restricted to production under terms that lodge much of the control with the contractor. Cf. [3, 14].

[12] It could go into various explorations, such as joint ventures. For an example of innovative thinking along this line, and instances such as Minute Maid's income-sharing with Florida Orange Marketers, see Goldberg [8].

In the balance between man, resources, and forms of economic organization, the first and last can no longer be shortchanged while attention is directed to combining a wealth of resources. A bridge must be built between man and his economic organization, and the nature of the human condition must be one abutment. The impersonality of the industrial system is too oppressive; it conflicts with man's history and his behavioral patterns. Man's acts, his failings, his derring-do have until lately been individually identifiable. Whether tending a herd or fashioning a sword or smiting with that sword, man struggled against nature or against man. Man cannot safely be submerged, and his socio-economic-political organization must accommodate his need for identity and expression.

The contract system of organization will not be discarded; rather, industrial democracy will be built into it. Institutional innovation that emerges will revamp commerce and industry. Agriculture, where the farming operation offers a conspicuous human role, is among the sectors most deserving of attention and promising of attainment. It should be possible to fashion agriculture and the rural community in a way to make rural regions a delight to their residents and a demonstration to all who are willing to watch and learn.

References

[1] Boulding, Kenneth E., *The Organisational Revolution*, Chicago, Quadrangle Paperbacks, 1968.

[2] Breimyer, Harold F., "Agriculture as Van and Rear in Institutional Change," *J. Econ. Issues* 4:43–53, March 1970.

[3] ———, "Who is Going to Control What Kind of Farming?" *Economic and Marketing Information for Missouri Agriculture*, Ext. Serv., Univ. of Missouri, May 1972.

[4] Campbell, William F., "Economics and the Machiavellian Tradition," *J. Econ. Issues* 5:20–30, June 1971.

[5] Center for Study of Democratic Institutions, "Self Management: Has its Time Come?" *Center Report*, Dec. 1971, pp. 3–4.

[6] Dahl, Robert A., *After the Revolution: Authority in a Good Society*, New Haven, Yale University Press, 1970.

[7] Fischer, John, "After the Revolution: the End of the Age of Affluence?" *Harper's* 242 (1450):12–18, March 1971.

[8] Goldberg, Ray A., "Profitable Partnerships: Industry and Farmer Co-ops," *Harvard Business Rev.* 50: 108–121, March-April 1972.

[9] Johnson, Glenn L., "The Quest for Relevance in Agricultural Economics," *Am. J. Agr. Econ.* 52:728–739, Dec. 1971.

[10] Knight, Frank H., *The Ethics of Competition*, London, George Allen & Unwin, 1951.

[11] Knutson, Ronald D., and William E. Black, *Who Will Control Agriculture? Alternative III, A Cooperative Agriculture*, North Central Public Policy Education Committee, Ext. Serv., Univ. of Ill. (forthcoming).

[12] Lerner, Max, "Introduction," in *The Wealth of Nations*, by Adam Smith, Modern Library Edition, New York, Random House, 1937.

[13] Madden, J. Patrick, and David E. Brewster, eds., *A Philosopher Among Economists, Selected Works of John M. Brewster*, Philadelphia, J. T. Murphy Co., 1970.

[14] Mighell, Ronald L., and William S. Hoofnagle, *Contract Production and Vertical Integration in Farming, 1960 and 1970*, USDA, ERS, ERS-479, 1972.

[15] Nell, Edward J., "Two Books on The Theory of Income Distribution: A Review Article," *J. Econ. Literature* 10:442–453, June 1972.

[16] Oberg, Winston, "Charisma, Commitment, and Contemporary Organization Theory," Michigan State University, *MSU Business Topics* 20:18–32, Spring 1972.

[17] Papandreou, Andreas G., *Paternalistic Capitalism*, Minneapolis, University of Minnesota Press, 1972.

[18] Prell, Michael J., "Index-Linked Loans," *Monthly Review*, Federal Reserve Bank of Kansas City, Nov. 1971.

[19] Robinson, Joan, *Economic Heresies*, New York, Basic Books, 1971.

[20] Roosevelt, Frank, "Reply to Bronfenbrenner," *J. Econ. Issues* 5:125–132, June 1971.

[21] Seaborg, Glenn, "The Cybernetic Age: An Optimist's View," *Saturday Review* 50:21–23, July 15, 1967.

[22] Shaffer, James Duncan, "On Institutional Obsolescence and Innovation—Background for Professional Dialogue on Public Policy," *Am. J. Agr. Econ.* 51:245–267, May 1969.

[23] Silk, Leonard, *et al.*, "Does Economics Ignore You?" *Saturday Review* 56:33–57, Jan. 22, 1972.

[24] "Too Many U. S. Workers No Longer Give a Damn," *Newsweek* 79:65, April 24, 1972.

[25] West, E. G., "Adam Smith and Rousseau's *Discourse on Inequality:* Inspiration or Provocation?" *J. Econ. Issues* 5:56–70, June 1971.

The Political Economy of Regional Water Institutions

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Water experts, prominent among them resource economists, typically suggest a unified regional organization as the appropriate institutional approach to an entire range of problems. Yet, the performance of multistate regional organizations has been disappointing. It is argued here that failure of regional institutions to innovate is largely determined by the restraints imposed by political viability. The article describes the political environment of regional organizations and the incentives and disincentives for various interests to associate themselves with regional organizations. Finally, various possible strategies whereby a regional organization can build support are outlined.

DESPAIRING over the prospects for policy innovation, A. Allan Schmid remarked in his paper on analytical institutional economics, "New programs, agencies and rules have promised much and delivered little in changed performance" [24]. The experience of multistate regional water institutions presents just such disappointment. The expectation of the designers is that regional entities will provide a comprehensive, coordinated, regional approach to water resources. In practice, it is extremely difficult to demonstrate that the fragmented, disjointed approach which typifies and, in the view of many, plagues water policy-making has been much altered by establishment of regional water institutions. This paper argues that failure of regional institutions to accomplish real innovation is associated with the restraints imposed by political viability. To be viable, that is, to survive, regional agencies have had to tailor their actions to build support. Support-building actions then compromise their ability to approach water and other resource problems in a comprehensive, coordinated, regional manner.

If social science research is to be relevant to the process of policy change, then the constraints imposed by political viability must be incorporated into institutional analysis. What is needed is a political economy model which includes the production and allocation of political resources. In the necessary research framework, the decision maker in water policy must be placed in the context of scarce political resources, weighing the relative costs and benefits of different courses of action [11, p. 56].

Most of the research on regional institutional arrangements has failed to include political factors. Instead, prescriptions are based on technical and economic concerns. Water experts, prominent among them resource economists, typically suggest a unified regional organization as the appropriate institutional approach to the entire range of problems—quality, quantity, enhancement of fish and wild habitat, water-based recreation, etc. The rationale is that basic facts of hydrology dictate that river basins be managed as a whole. Further, characteristics of the economic system suggest that management be organized on a sufficiently broad scale to internalize the major externalities involved in water use [14]. A basin-wide agency, it is argued, can achieve economies of scale and optimal rationality in site selection for water projects [20, 21]. The ideal posed has been geographic congruity between the water-related task to be performed and the areal jurisdiction of the planning and administering unit [15]. Since river basins seldom follow existing state boundaries, water experts have recommended creation of subnational organizations which overlay the regular federal system.

A variety of regional organizations has been experimented with during this century. Beginning with the Colorado River Compact of 1922, more than 30 compacts have been negotiated among states dealing with associated water problems in a variety of ways. Many, particularly those in the West, have been water allocation compacts. Others have been aimed at limited coordinating efforts such as flood and pollution control. A few compacts have established commissions with limited regulatory authority such as the Ohio River Valley Water Sanitation Compact (ORSANCO). Compacts with the most comprehensive authority are the federal-regional compacts including the Delaware and Susquehanna compacts and the nearly completed Potomac compact. The Tennessee Valley Authority is a unique regional

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arrangement for planning and developing water resources in a river basin which comprises parts of seven states. It is a wholly owned federal government corporation with broad authority in flood prevention, improvement of navigation, electric power development, and other resource activities. In the 1940's and 1950's numerous federal interagency coordinating committees were established in river basins, and ad hoc coordinating committees were set up from time to time to coordinate the planning of federal construction agencies in particular basins for specific studies. River basin commissions replaced some of the interagency and ad hoc committees after passage of the Water Resources Planning Act of 1965. There are now seven river basin commissions with joint federal and state membership whose principal functions are preparing a comprehensive, coordinated plan for water and related land resources. Congress created a number of regional economic development commissions in 1965 to foster expansion by various means including the development of water resources. None of the experiments with regional organizations has been altogether successful. There is not one organization whose achievement stands out as clearly better than the rest.

The tendency among water resource experts has been to look at the design of various regional institutions to explain the causes of failure. Questions have been debated whether a regional agency must have implementing and regulatory as well as planning authority, and whether its scope of jurisdiction should be restricted to specific issues such as water quality, the subject of water generally, or, more broadly, natural resources and the environment. The likelihood of success has been linked to the existence of an independent staff and leader and adequate funding. Variations in existing regional institutions' organization and membership have been scrutinized in terms of inclusiveness and capacity to make decisions [3, 9, 16]. The perspective of this author is that regional agencies, regardless of their specific design, are challenged by common problems of political viability. The intention here is to explore the dimensions of this common problem and describe the strategies which regional organizations have employed to achieve political viability.

Although there is extensive literature on regional organizations, little has been written which focuses upon political resources or the choice of decision makers in a context of scarce political resources. Sources of information and analysis cited below were selected because they dealt, in whole or part, with questions of political support for various regional organizations.

The Regional Environment

A regional organization is not created into an empty world. Instead, a web of relationships already exists among federal, state, and local agencies and interest groups. A regional organization must fit into, and, if it is to have substantial impact, alter and redirect these relationships. A regional agency must possess and maintain support for its operations. As Warren and Wandesforde-Smith in their excellent analysis of regional arrangements in the Columbia River Basin have stated:

> A new subnational agency must be imposed upon a system of behavior, or regional political system, in which many existing jurisdictions have a capacity to influence the new agency. Their influence may extend to the planning, coordination, and program the new agency can adopt and the degree of success its policies enjoy. [26, p. 14]

The regional setting of an institution has an important impact upon its viability.

The extent of regional consciousness on regional interest is a significant variable. Some regions such as New England and the Old South have a particular sense of identity and a long history of cooperation. In a federal system most allegiance to geographic areas is focused on particular states and the nation. There is no solid evidence that social awareness of regions is on the increase. Still, all other things being equal, the integrating and coordinating task of a regional institution should come easier in a region which has had practice at getting together.

Traditionally, water has not been a subject which raises the level of regional cohesiveness. The politics of water have been essentially local politics with each locality focusing on its particular water problems. In the West the struggle to get a fair share of water supply has divided locality from locality and state against state. No less parochial view is evidenced in the East, where there is a tendency for each community to develop its own water supply, and regional solutions are not ordinarily considered unless the cost of independent sources of supply becomes prohibitive [10].

Motivations for establishing a regional organi-

sation and the extent to which they are coherent and consistent are important to the organization's long-term political viability. It cannot be assumed that establishment of a regional water resource institution represents political recognition of its river basin character or a predisposition toward regional coordination and agreement. River basin institutions have been motivated by a variety of specific causes. The Pacific Northwest River Basin Commission was established to provide a united front against the threat of an interbasin transfer of water from the Columbia to the Southwest and to obtain some promised federal subsidies for state water resources planning [26, p. 18]. Defense against federal intervention was a major inducement to New England states in drafting the Northeastern Compact and, upon failing to get Congressional approval for the compact, for the establishment of the New England River Basins Commission which they felt would strengthen the states' hand against federal agencies [12, p. 18]. Negotiations leading to the signing and ratification of the Delaware River Basin Compact reveal among the major actors serious differences which threatened to mar their unified, regional approach to water resources. The states within the Delaware basin were prompted by a desire to cut down the autonomy of the federal agencies and to bring decision making back from Washington to the region. Understandably, federal agencies were skeptical and suspicious, and the federal government insisted upon multiple reservations to the compact [3, p. 102]. As the above examples indicate, agreeing to a regional institution does not constitute agreement upon regional aims and goals the agency should pursue, or even a commitment to make the regional institution work.

The values and preferences of individuals in key positions in water-related activities in the region are important attributes of the environment. In a specialty like water, the people active in a region may remain the same over the spans of their careers. Carry-over of personnel introduces a certain inertia into institutional change. Warren and Wandesforde-Smith found that many of those who occupy high posts in the Pacific Northwest River Basin Commission have been associated with water-related agencies and groups for more than 30 years and in some cases for a longer period. Similarly, a staff director of the New England River Basin Commission was formerly a representative of Massachusetts on the New York-New England InterAgency Committee, and members from the Department of Interior and the State of Connecticut on the interagency committee also carried over to the river basin commission. The result of such long involvement is that although regional institutions change, the attitude of important decision makers about coordination within the region and relationships among important decision makers are more constant parts of the environment.

The foregoing analysis indicates that the regional environment for regional organizations is frequently not conducive to their growth and development. A common regional viewpoint may well be lacking. Establishment of a new organization may have little effect upon the personnel who make decisions. Consequently, a regional agency in order to insure survival must look to sources of support among the interests in the region.

Interests Within the Region

Underlying the fragmented decision-making system in which the allocation of water resources is ordinarily made within a region are different and often conflicting interests. According to Lyle Craine [4], "The primary issues confronting a basin-wide agency stem from conflicting goals based upon various values and public preferences expressed and supported by different political constituencies." If a regional agency is to accomplish coordination and coherence, it must establish a positive balance of support. Its decisions must prompt more applause than boos from the interested public. Consequently, orientation of the important interests in a basin toward regional institutions is crucial to success. If they are to support and alter their behavior to comply with regional institutions, they must somehow see their interests served. Following is a listing of the major interests within regions and their orientation toward regional water institutions.

1. *States* represent important interests within the region. In general, states have been reluctant to give up autonomy to regional bodies. As noted above, inducement for combination has been to ward off federal influence, not necessarily a sense of regionalism. Whether states, in fact, are motivated to coordinate their water-related actions through regional bodies depends upon the salience of water as an issue, the extent to which a regional strategy serves particular state interests, and the individual

capacities of states to participate in regional institutions.

Water is regarded as "liquid gold" in some arid Western states, and state governments have squared off against each other in historic legal struggles over water rights. In other states water has been a much less important issue, overshadowed by more immediate social problems and pushed off the active agenda of most state leaders. Federal agencies have historically taken the initiative in water development, and as one state official assessed the experience, "By and large, the states have been content to let someone else do their planning and then cry about the results" [25].

Interstate rivalry between Arizona and California over the division of Colorado River water demonstrates that even when water is important, states frequently see benefit in an individual rather than regional strategy. The Colorado River Compact of 1922 was useful to states because it afforded legal protection to specific separate interests, not because it was a rational basin approach. Within a river basin there is likely to be considerable variation in the willingness of states to cooperate and coordinate. Upstream-downstream splits are common. The northern New England states, for example, have far less to gain from a regional flood control program than Massachusetts and Connecticut [8]. Similar divisions exist in the Pacific Northwest [26].

A Minnesota representative on the Great Lakes River Basin Commission presented that state's perspective on regional water arrangements:

> . . . the state has only a secondary interest in the multi-state regional aspects of managing its water resources. From Minnesota's point of view, not many of its water problems are susceptible to solution or amelioration by the action of other states. The small number of water problems that Minnesota can identify can be handled usually by its own State agencies working with representatives of local governments and private industries. A few problems require the assistance from one or more Federal agencies, and, on occasion, a neighboring state may need to be consulted. But there is relatively little that a multistate body can do to assist Minnesota to achieve its objectives in water resources management. [13, p. 7]

With such little stake, it is not surprising that a state is reluctant to fund, participate in, and tailor its behavior to fit regional water institutions. Of course, if regional bodies serve as conduits of large federal funds, the interest of the state may possibly become much greater.

The capacity of states to participate in regional bodies varies from state to state, but overall it is not great, especially when compared with that of federal agencies. Participation in coordinating bodies can be a drain upon state resources. Again, Minnesota's experience is illustrative.

> Minnesota lies in four separate river basins. It receives a matching grant from the Water Resources Council to help defray some of the costs of working with these regional planning bodies. The amount of that grant is not nearly sufficient to pay for active participation in all four of these bodies, having as they do a combined total of 115 work groups. One consequence, then, is that federal agency representatives perform most of the work in preparing the group's plan document. [13, p. 6]

2. *Federal agencies*, whether or not their representation is formally consolidated as in federal-interstate compacts, represent diverse interests with which a regional body must cope. Federal agencies have their own aims, goals, and constituencies and can be expected to serve them. Individual water agencies have their own shelf of project plans which they dream of constructing and their own lines to local interests which benefit from projects and supply continuing support for the agency program. Under certain circumstances individual agency objectives can be served by working through regional institutions. If coordination among federal agencies and cooperation with states implies approval of agency plans with less conflict, then federal agencies are likely to cooperate with regional entities. Federal construction agencies have been increasingly willing to work through coordinating bodies such as basin committees and commissions and the Water Resources Council. Experience has demonstrated that open interagency competition evokes Congressional displeasure and provides leverage to the opponents of water development. Through communication facilitated by regional coordinating committees and the layering of agency plans, agencies can avoid collision.

Under certain circumstances a regional institution can provide support, or at the very least act as a buffer, for federal agencies. Where a federal agency can get a regional body to adopt its plan as the regional plan, its interests might well be furthered by supporting the regional institution. The Pacific Northwest River Basin Commission, for instance, has been pressed by the Bureau of Reclamation to adopt the Westwide Study. The Delaware River Basin Compact Commission chose to adopt the Army Corps of Engineers water plan for the region and it is probable that the Susquehanna Compact Commission will do likewise. The Office of Appalachian Studies, a group specially formed within the Army Corps of Engineers, prepared the Appalachian Water Plan for the Appalachia Regional Commission. New England provides an example of a regional agency operating as a buffer. The Army Corps of Engineers is currently *bête noire* to many conservation groups, and any project the Corps undertakes is immediately suspect. Insofar as the New England River Basins Commission is considered a disinterested party by the Corps' detractors, its consent for projects represents a valuable achievement for the Corps.

The less dominant federal agencies in a region may have a larger voice in decision making through a regional organization. Interagency cooperation and planning has regularly benefited the Soil Conservation Service's small watershed program. As a participant in coordinating committees, the SCS has received consent for projects which the agency would have had difficulty in justifying on its own. The regional representative of the Department of Interior in New England states that its agencies had greater influence over the Corps by working through the New England River Basins Commission [12, p. 16].

Under other circumstances, the aims of federal agencies can be better served by opposing establishment of regional institutions and working around them once they are established. Where a federal agency is dominant in a region, it may well be reluctant to share its power with other agencies, including regional entities. Fox and Picken [7] and Pealy [18] have documented the reluctance of the Army Corps of Engineers to share its hegemony over mainstream flood control in the Arkansas White-Red river basins. Agencies are likely to object even more strongly when regional agencies threaten to displace their activities in a basin. Longstanding opposition to any replication of the Tennessee Valley Authority has come from federal agencies whose activities have been either cut out or circumscribed in the valley. Similarly, federal agencies were the focus of opposition to the Delaware River Basin Compact, and many of the federal reservations were motivated by agencies' concerns to maintain an operating base in the basin.

3. *Private interests*, including commercial, industrial, developmental, and environmental interest groups, are important actors in the region and their position *vis-à-vis* regional entities is crucial to political viability. Especially if a regional entity endeavors to take policy positions which diverge from those of other governmental actors, the states, and federal agencies, approval and support of a constituency of private interests are essential.

Interest groups operate under the strictures of a resource budget in their relations with governmental entities. They have only so much time, energy, staff, and funds to expend, and they naturally want to focus their activities upon priority decision points. Established positions of authority such as state and federal agencies are likely to have preferred status over regional entities. Longstanding agency-clientele relationships exist between federal and state agencies and the publics they serve. Interests are most apt to focus on salient, eminent decisions. Because of the remote impact of river basin planning decisions, it has been difficult to motivate private interests to make much of an input into regional planning studies. Nothing happens to many plans, even authorized ones, as illustrated by the $15 billion backlog of authorized water projects. If plans come to fruition, it is often far in the future. The average time for the planning and construction of civil works projects by the Army Engineers is currently 17 years and 11 months. The level of importance of the decisions which regional entities make also affects the degree of attention and support deriving from private interests. Private interests are unlikely to pay much attention if what a regional agency does is routine rather than innovative.

Private interests are more likely to relate to regional agencies if they present an alternative, more sensitive decision point than federal and state agencies. Environmental groups have provided particular support to the New England River Basins Commission because they believe its chairman, who has a strong conservation record, is more sensitive to environmental impacts than other governmental entities [12, p. 23].

4. *Governors* have interests of their own apart from general state interests. Their support, opposition, or inattention affects a regional en-

tity's political viability. The perspective which a governor has on regional bodies is shaped by his role and the pressures under which he must work. A governor has one or two terms in which to make whatever impact upon policy he is to make, and he must build popular support in his first term if he is to have a second. The governor's power resources vary from state to state. Often, he has difficulties controlling an administration in which agency personnel have much longer tenure. He usually wins the approval of state legislatures only after tough, protracted effort.

Historically, governors have not usually exploited regional institutions. They are often separated from their counterparts in other states in the region by national political affiliation. Governors' conferences typically skirt substantive issues which might produce conflict. A governor's principal obligation must be to his own state. Regional programs are of political interest to the governors primarily if they have clearly visible impact on solving critical state problems. Regional water programs, unless they are associated with an immediate crisis such as a flood or connected with a broader environmental program, are not ordinarily of the magnitude of importance to attract much attention. Further, the time span under which regional organizations often operate frequently does not square with gubernatorial needs. Planning agencies, for instance, often work in a long time frame.

Under certain circumstances, governors may be attracted to working through regional organizations. The support of a regional body may lend weight and credibility to a policy a governor wants to pursue in his state. Regional bodies may promote measures which governors have difficulty promoting directly. Flood plain management, which local governments find distasteful and often oppose, is an example [2]. If regional bodies serve as a conduit to states of federal funds which individual states cannot tap on their own, then governors have somewhat stronger inducements for cooperation.

Alternative Strategies of Regional Organizations

If a regional agency is to grow and survive, it must build a positive balance of support among the interests which are predominant in the region. The design, membership, structure, decision rules, jurisdiction, and authority of a regional organization strongly affect the strategy which a regional agency pursues in putting together a basis of support within a region. It has not been possible, however, to design an agency which is immune to its political environment, even if this were desirable. Following are examples of strategies which different regional entities have pursued to maintain political viability.

The grass roots strategy dictates an orientation toward local and private interests as the basis of support. The Tennessee Valley Authority is the classic example of this strategy [23]. TVA was created during a period of crisis with the backing of a powerful president. It was afforded a number of autonomies and freedoms which insulated it from federal executive and Congressional control. At the same time this unique federal corporation was cut off from the federal establishment as a source of support. In its precarious position, TVA took special pains to cultivate the strong support of the people and the power centers of the region. It worked to complement rather than to replace the influence of local governments and private interests. Three examples will suffice to illustrate TVA's grass roots strategy. First, in its power program TVA restricted its operations to wholesale production and distribution. Not only did it leave the retailing to be done by local organizations, but also it encouraged the formation of consumer cooperative groups. Second, in its fertilizer program TVA decided to concentrate on research and development at the region's universities and by demonstration projects to promote enlightened use of fertilizer with various of the region's agricultural groups. Thirdly, in its sponsorship of planning TVA promoted a high planning capability in states and localities rather than doing all planning itself [1]. In his well-known study of the TVA, Philip Selznick concluded:

> . . . The Authority's grass-roots policy as doctrine and as action must be understood as related to the need of the organization to come to terms with certain local and national interests; and that in actual practice this procedure resulted in commitments which had restrictive consequences for the policy and behavior of the Authority itself. [23, p. 12]

The most heralded experiment in integrated, multipurpose water resources development has thus fallen far short of expectations. The grassroots strategy has meant that TVA is much less than a fully integrated water resource management agency for the Tennessee River basin. It has divested itself of responsibilities that related primarily to local communities of interest and concentrated on a narrow range of problems related to flood control, power production, and navigation. Other purposes are integrated only as other cooperating agencies are willing to coordinate their programs with TVA [17, p. 67].

The Ohio River Valley Water Sanitation Compact (ORSANCO) represents a variation on the grass roots strategy. Industrial interests in Pennsylvania were effective in blocking the ratification of the compact until they became convinced that federal intervention was likely. The compact document itself, adopted in 1948, was a conservative one, and in practice, with respect to industrial waste discharges, the commission defers wholly to the member states for regulation. The commission has authority to issue enforcement orders and bring polluters to court, but it has exercised its enforcement power only six times in the course of eighteen years, and in none of these instances has the case gone to court. Infrequent use of enforcement powers is due to the fact that action can be taken only if a majority of the commissioners from a majority of the member states agrees, and then only if a majority of the commissioners from the state from which the pollution originates assents [5, p. 135]. Enforcement against water pollution in the Ohio Valley under ORSANCO lags behind the rest of the nation [16, pp. 64–94]. A strategy of deference to states and the private industrial interests they represent limits the achievements of the compact.

The governors' strategy is most obviously exemplified in the Appalachian Regional Commission established in 1965. A conference of Appalachian governors organized in 1960 to press for federal aid to the region. President Kennedy responded with programs through the Area Redevelopment Administration, but this approach failed to satisfy the governors who argued it was an underfunded and piecemeal approach. In 1963 the President's Appalachian Regional Commission was formed to prepare a plan. The resulting ARC program was shaped by the participation of the governors and is sustained by that participation today. Procedures of the ARC call for recognition of state-identified growth centers where investment is to be concentrated. Program composition by state is determined by interstate negotiation with major approval and often development assistance of each project by the state [22]. Appalachian governors support the commission as a conduit of federal funds to the region. This strong basis of support has had implications for the policies pursued. One view is presented by the Ash Council Report which stated:

> The plans of the Appalachian Regional Commission are essentially in aggregation of separate state investment plans. Commission funds tend to be divided among states according to formulas based on population or some measure of need. There is little evidence that economic development priorities, strategies or projects have been established on a regional basis. [19, p. 53]

A strategy of compromise and moderation implies not alienating any potential supporters and is well illustrated by the Delaware River Basin Compact Commission. Although under law the Delaware Commission can act by majority vote, the position of the federal member is legally murky. In practice, the commission has operated under general agreement. Federal agencies were excluded from the negotiations of the Delaware Compact and were faced with almost overwhelming political support for the compact in Congress. The federal agencies' first line of defense was to tack on numerous "reservations" to the compact, preserving a whole host of federal interests. The very uncertainty surrounding the reservations appears to have created an atmosphere conducive to, if not compelling, consensus among federal and state members [16].

Although there is considerable debate over the achievements of the Delaware River Basin Commission, there is general agreement that it has never really exercised the considerable power it was granted. The strategy of moderation, where no toes are stepped on, may condemn a regional institution to not doing anything innovative. The Delaware Compact Agency has not created a comprehensive plan. The major plan for water control in the Delaware Basin was a Corps of Engineers-led planning effort which the agency adopted. The commission's record with respect to pollution control is considered by some to be very modest on the grounds that it was not motivated to act under its very adequate authority until enactment of the 1965 Federal Water Pollution Control Act amendments. While the commission did act, so did most other agencies including the states within the Delaware on other waters within those states [6, p. 15].

The federal agencies' strategy has been chosen by many river basin commissions set up under

Title II of the Water Resources Planning Act. Although these commissions are designed to give equal status to both federal and state agencies, their activities are those in which federal agencies have superior resources and which particularly benefit federal agencies. Much commission effort is put into planning studies, and federal agencies are specially funded and staffed to participate in such efforts. In contrast, states are underfunded and understaffed. Out of planning efforts eventually come projects which federal agencies can build. No such obvious pay-off accrues to states. A common problem identified by reviewers of Title II River Basin Commissions has been a failure to serve the interests of states so well as those of federal agencies [3, 9, 12].

Conclusions

A thorough catalogue of the strategies pursued by regional organizations might well uncover other types and certainly some examples of mixed strategies. The New England River Basins Commission, for example, has followed a double path of appealing particularly to the governors and the environmental groups in the region [12]. A complete review is less the point here, however, than is illustration of the pervasiveness of employing strategies to maintain political viability.

Herein lies a lesson for the sponsors and designers of regional agencies. Under most circumstances an integrated comprehensive treatment of water resources cannot be organized within the framework of a single integrated agency. Too many values are at stake in relation to too many different communities of interest [17]. Where interests are conflicting and there is no agreement on goals, the necessary ingredients for cooperation and coordination can not be created by establishing an organization. The resource economist who fails to take into account the restraints of political viability in making organizational recommendations risks disillusionment when the organization fails to perform.

Examples of the Tennessee Valley Authority and the Delaware River Basin Compact illustrate that political considerations cannot be sidestepped by granting a regional organization more formal authority. Where there are fragmented and conflicting interests with their own resources of power and authority, then decisions are going to be made by a process of negotiation and consent-building, not by the fiat of a regional agency.

Unquestionably, there are aspects of water and other resource problems which require some kind of regional treatment that can be facilitated by a regional organization. Where regional agencies are desirable, then selection of attributes, including organization, membership, jurisdiction, and authority, must be made with a view to the political environment of the region in which it is to operate and the basic requisite of political viability. If a regional agency is to act and not be captured by particular interests with strong positions in the region, then adequate sources of support must be identified by designers.

Furthermore, regional entities must be given the tools with which to cope with the interests of the region and elicit their compliance. Attention needs to be given to the sort of inducements that would commit states to regional organizations, including funds funneled through regional bodies, requirements for participation in regional planning for federal grants-in-aid, and other means. Similar thought needs to be given to incentives which could prompt federal agencies to give their full cooperation to regional bodies. Designers also need to prepare for public involvement in regional organizations. Most regional agencies until now have had a very low public profile. If regional agencies are to fulfill meaningful objectives, then public recognition and support are likely to be basic ingredients of viability.

Future social science research on regional water institutions should be more broadly focused than much of what has been done in the past. A political economy model needs to be employed which includes the production, allocation, mobilization, and exchange of political as well as other resources. Only such a model can realistically illustrate and explain the behavior of decision makers who operate under conditions of scarce political resources and who must have support for their actions if the benefits to the decision makers are to exceed the costs involved.

References

[1] ADLER, OLIVIA, *Interim Report on the TVA to the National Water Commissions*, National Water Commission Files, 1971, mimeo.

[2] ALLEE, DAVID J., AND HELEN M. INGRAM, *The Authorizations and Appropriations Processes in Water Resources Development*, Report to the National Water Commission, 1972.

[3] Advisory Commission on Intergovernmental Relations, *Multistate Regionalism*, Commission Report A-39, Washington, D. C., U. S. Government Printing Office, April 1972.

[4] CRAINE, LYLE E., *Final Report on Institutional Arrangements for the Great Lakes*, a report to the Great Lakes River Basin Commission, 1972.

[5] DAVIES, J. CLARENCE, III, *The Politics of Pollution*, New York, Pegasus, 1970, Chap. 6.

[6] DWORSKY, LEONARD B., Letter to Theodore Schad in review of Muys Study, January 3, 1972, National Water Commission Files, Arlington, Virginia.

[7] FOX, IRVING K., AND ISABEL PICKEN, *The Upstream-Downstream Controversy in the Arkansas White-Red Basins Survey*, ICP Case No. 55, University, Ala., University of Alabama Press, 1955.

[8] GERE, EDWIN ANDRUS, *Rivers and Regionalism in New England*, Amherst, University of Massachusetts, Bureau of Government Research, 1968.

[9] HART, GARY W., *Institutions for Planning*, Report to the National Water Commission, 1971.

[10] HOWARDS, IRVING, AND EDWARD R. KAYNOR, *Institutional Patterns in Evolving Regional Programs for Water Resources Management*, Water Resources Research, Amherst, University of Massachusetts, 1971.

[11] ILCHMAN, WARREN F., AND NORMAN THOMAS UPHOFF, *The Political Economy of Change*, Berkeley, University of California Press, 1969.

[12] INGRAM, HELEN, *The New England River Basins Commission: A Case Study*, Report to the National Water Commission, 1971.

[13] KELNHOFER, GUY J., "Regional Water Resources Planning: One Man's Perspective," paper presented to the Interstate Conference on Water Problems, Cincinnati, February 2, 1971, mimeo.

[14] KNEESE, ALLEN V., AND BLAIR T. BOWER, *Managing Water Quality: Economics, Technology, Institutions, Parts IV and V*, Baltimore, The Johns Hopkins Press for Resources for the Future, Inc., 1968.

[15] MARTIN, ROSCOE C., *et al.*, *River Basin Administration and the Delaware*, Syracuse, Syracuse University Press, 1960, Chap. 5.

[16] MUYS, JEROME C., *Interstate Water Compacts*, Report to the National Water Commission, 1971.

[17] OSTROM, VINCENT, "The Water Economy and Its Organization," *Natural Resources J.* 2:55–73, April 1962.

[18] PEALY, ROBERT, *Comprehensive River Basin Planning; the Arkansas White-Red Basins Interagency Committee Experience*, Michigan Governmental Study No. 37, Ann Arbor, 1959.

[19] President's Advisory Council on Executive Organizations, Memorandum for the President of the United States on the Organization for Social Programs, Appendix 9, 1971.

[20] ROBERTS, MARC J., "Organizing Water Pollution Control, The Scope and Structure of River Basin Authorities," *Public Policy* 19:75–142, Winter 1971.

[21] ———, "River Basin Authorities: A National Solution to Water Pollution," *Harvard Law Rev.* 83:1527–1556, May 1970.

[22] ROTHBLATT, DONALD N., *Regional Planning: The Appalachian Experience*, Lexington, Mass., Heath Lexington Books, 1971.

[23] SELZNICK, PHILIP, *TVA and The Grass Roots: A Study in the Sociology of Formal Organization*, New York, Harper and Row, 1949.

[24] SCHMID, A. ALLAN, "Analytical Institutional Economics: Challenging Problems in the Economics of Resources for A New Environment," Paper presented to the American Agricultural Economics Association, Gainesville, Florida, Aug. 22, 1972.

[25] SPARKS, FELIX L., speech, Colorado Water Conservation Board, Colorado State University, Fort Collins, Sept. 10, 1969.

[26] WARREN, ROBERT, AND GEOFFREY WANDESFORDE-SMITH, *A Comparative Analysis of American and Canadian Governmental Arrangements for the Development of Regional Water Policy in the Columbia River Basin*, Seattle, Office of Water Resources Research, September 1970.

Application of Multivariate Probit to a Threshold Model of Grain Dryer Purchasing Decisions

LOWELL HILL AND PAUL KAU

Purchase of grain dryers by farmers can be explained using a threshold theory of decision in which a reaction occurs only after the strength of the stimuli increases beyond the farmers' reaction threshold. Estimates of the causal relationships in this dichotomous decision model were obtained by using the probit technique with data from a farmer panel. The results provide an explanation of differences in the number of dryers purchased by farmers in various classes and regions. It also provides a procedure for predicting dryer ownership and purchases of dryers as an aid to forward planning by distributors of drying equipment.

THE decision to purchase a durable factor of production such as a grain dryer may be characterized as a dichotomous choice between two mutually exclusive alternatives. The dichotomous nature of such a decision implies that there exists a "breaking point" or threshold in the dimension of the explanatory variable below which a stimulus elicits no observable response. Only when the strength of the stimulus reaches the threshold level does a reaction occur. Additional increase in stimulus strength results in no effect on the observed response.

Predicting and explaining these kinds of economic decisions and behaviors requires specialized models to identify the relevant economic stimuli, to provide information on the magnitude of their effects, and to estimate the threshold levels of responses.

Although studies have been made of economic decision processes [15, 18, 20, 23], none have adequately integrated the theory of the threshold concept and the operational statistical techniques into an economic model. Nourse [21] and Berry [2] referred to the concept in their studies of market areas and centers but applied the term only to the problem of minimum size of firm. Bilkey [3] in a study of consumer expenditures implied the threshold concept in his vector analysis, although he did not explicitly develop a threshold theory or attempt to measure the threshold levels. Models developed by Tobin [25], Rosett [22], and Dagenais [5] can be used to estimate parameters for dichotomous problems, but no explicit connection was made between decision theory, the threshold concept, and statistical techniques. These models focused primarily on limited regressand problems.[1] Tomek [26] discussed the dichotomous regressand problem and related statistics but like Tobin and others did not relate his study to the theory of threshold reactions. In contrast, modern psychologists such as Heckel and Jordan [10] and Isaacson, Hutt, and Blum [14] emphasize the important relationship between the threshold concept and human decisions or behavior, but their approaches are mainly conceptual rather than operational and quantitative.

Integration of the theoretical and statistical models is important in explaining and predicting dichotomous decisions and behavior. Objectives of this paper are to explicate the threshold concept in terms of a multivariate probit model[2] and to apply this model to farmers' purchases of grain dryers in order to estimate probability of purchase and identify the causal factors in the decision.

Theoretical Framework of the Model

For convenience, assume a decision variable, Y, which is designated as the dependent variable in an equation with only one explanatory independent variable, X. If the observed Y is defined in the context of probability, then Y will take only two values: $Y=1$ if the decision results in an action and $Y=0$ if it results in no action. The dichotomous nature of this kind of decision is illustrated by the line $ATUB$ in Figure 1. Point T represents the "breaking point" which, in terms of psychology, is referred to as the "limen" or "threshold." At values of X greater than T there is a probability of 1 of posi-

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[1] Despite a similarity between the limited regressand problem and the threshold concept, a dependent variable that is inherently bounded by an upper and/or a lower limit does not necessarily imply the existence of a threshold.

[2] The estimation procedures of this model are mainly based on Finney's probit analysis and Tobin's extension [7, 25].

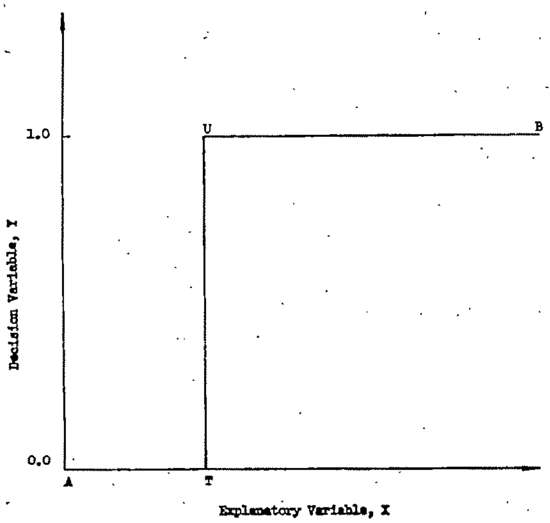

Figure 1. An individual decision threshold

tive action or decision. At values below T the probability is zero.

When the decision variable, Y, takes on only values of 0 or 1 and the thresholds of all members in a sample are distributed among different values of the explanatory variable (e.g., T_1, T_2, T_3, $\cdots$, T_n in Figure 2), then the expected functional relationship of the threshold decision model would resemble a sigmoid curve. A distribution of thresholds within a random sample would be expected because of individual differences such as personality, preferences, educational background, philosophy of value, etc.

Yamane [27, p. 123] has suggested that the sum of a number of independent random variables is asymptotically normal regardless of the distribution of the individual variables. Since the threshold of an individual is influenced by numerous variables focused into a single response, distribution of thresholds in a large sample of individuals can logically be assumed to be normal, and the expected functional relationship between the expected purchase of a dryer and the explanatory variables will be a normal sigmoid curve such as AB in Figure 2 [6, p. 178].

The main characteristic of a normal sigmoid curve is the existence of sections in the lower and upper ranges of the explanatory variable (or variables) in which an increase in the explanatory variable would not exert any (or at most a negligible) influence on the value of the decision variable. A sensitive response in the decision variable can be observed only in the segment between the two extremes [7, pp. 8–47]. The end-point of the lower range may be regarded as the "threshold" of that explanatory variable. Beyond the threshold point, a normal sigmoid curve first increases at an increasing rate and then increases at a decreasing rate, finally reaching a maximum at a probability value of 1. Therefore, the sigmoid curve is a functional form which represents the threshold concept.

Methodological Considerations

Many methodological problems are encountered in estimating relationships in which the dependent variable is dichotomous [5, 8, 26, 28]. Although the linear probability function is frequently used to approximate relationships in a threshold model, this technique has several serious limitations, including: (1) The disturbance term exhibits heteroscedasticity [8, p. 249]; and (2) The expected value of Y may sometimes be greater than 1 or less than 0 [5, 8].

Use of Aitken's generalized least squares will overcome the heteroscedasticity problem; however, further difficulties will be encountered in determining the weighting factor

$$\frac{1}{\sqrt{E(Y_i)[1 - E(Y_i)]}}$$

if $E(Y_i) > 1$ or $E(Y_i) < 0$ or if the variance-covariance matrix is singular [8, p. 250].

To handle the problems of $E(Y_i) > 1$ and $E(Y_i) < 0$, both the simpler method of truncat-

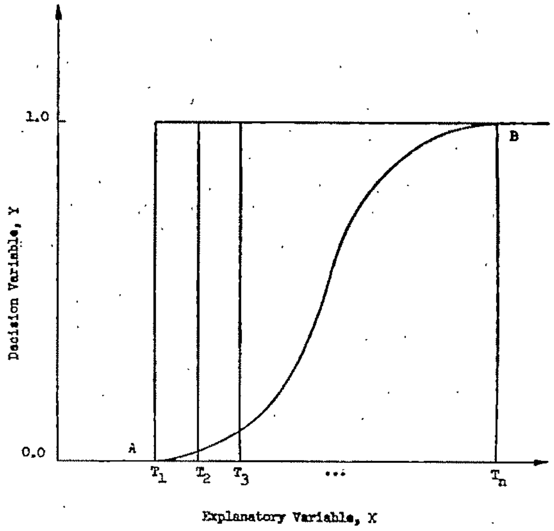

Figure 2. Functional form of aggregated decision thresholds

ing Y values [9, 13] and the more complicated procedure of restricted least squares in conjunction with quadratic programming [19] have been proposed.

Several other techniques have been suggested including logit [1], gompit [4], and Zellner and Lee's joint estimation techniques [28]. The method of discriminant analysis is also appropriate for answering some questions related to models having a dichotomous dependent variable.

The probit model selected for use in this study has several desirable characteristics when used to estimate parameters of a threshold decision model. Probit, as systematized by Finney [7] and extended by Tobin [24, 25], determines the decision variable Y by $Y=0$ if $X<X^*$, and by $Y=1$ if $X \geq X^*$. It is clear that X^* plays the role of a "breaking point," and thus the threshold concept is explicitly incorporated in the model. In a multivariate case, an aggregated variable A is assumed such that A is a linear combination of the explanatory variables, with A^* as threshold playing the role of disturbance forces. The disturbance term is therefore homoscedastic in the probit approach [8, p. 250]. The final equation derived from the probit model is $E(Y_i|A_i)=\text{prob}\ (Y_i=1|A_i)=F(A_i)=F(B_1X_{1i}+B_2X_{2i}+\cdots+B_mX_{mi})$ [8, 24]. Since F is the normal cumulative function, whatever value A_i takes will necessarily be transformed into the interval of zero and unity, and the difficulty of $E(Y_i)>1$ or $E(Y_i)<0$ is overcome. Moreover, the derived functional form between A and Y is a normal sigmoid curve [7]. Therefore, any linear or nonlinear relationship between X and Y through A can be accommodated, and the threshold decision model can be represented.

An additional property of the multivariate probit model is that the magnitude of the effect of the relevant economic stimuli depends upon the status of the economic unit as well as upon the magnitude of the estimated coefficient, $\hat{B}_j$. To state this more rigorously, $\Delta E(Y_i)$ is a function of A_i and ΔA_i, where $\Delta A_i=\hat{B}_j(\Delta X_{ij})$. For example, an increase of the ith farmer's farm size, X_{ij}, will increase his probability of deciding to purchase a dryer. The amount of increase in probability is determined not only by the magnitude of ΔA_i (as in ordinary regression), but also by the initial value of A_i before the change in X_{ij} takes place. Therefore, the effect of a 1 percent increase in farm size depends on the initial size of that particular farm. This is consistent with both economic theory and empirical observation of decisions involving a threshold concept.

Analytical Model

Economic feasibility of purchasing a dryer depends on the relative profitability of alternative uses for resources as well as on the cost of drying. The choice between on-farm and off-farm drying is therefore influenced by the economic organization of farm enterprises and by the characteristics and attitudes of individual farmers. Both A (the aggregated index of the explanatory variables) and A^* (the threshold level) vary among farmers. To explain and predict the decision for individual farmers or groups of farmers, it is necessary to identify and quantify relationships between the variables that comprise A and the purchasing decision, Y.

It was hypothesized that the variables of farm size, farm type, method of harvest, farm ownership, shelled corn storage capacity, percent of grain sold at harvest, and age of the farmer were significant variables in an explanatory model of farmers' decision to purchase a grain dryer.[3] The multivariate probit model was formulated as follows to estimate the parameters involved in these relationships:

Let

$$Y_i=\begin{cases} 0, & \text{if } A_i<A_i^* \\ & \qquad\qquad \text{for all } i,\ i=1, 2, \cdots n \\ 1, & \text{if } A_i \geq A_i^* \quad \text{observations.} \end{cases}$$

Where

$A_i=B_1X_{1i}+B_2X_{2i}+\cdots+B_mX_{mi}$

m = number of independent variables

A_i^* = the threshold level of the ith farmer.

$X_1=1$ for all i.

X_2 = farm size as measured by acres of corn harvested.

X_3 = farm type where a livestock farm feeding over 500 head of hogs annually is coded 1 and all other farms are 0.

X_4 = percent of total corn production harvested as shelled corn.

X_5 = reflects ownership of a home base of operations and is coded 1 if the farm operator rented all of the acres operated; otherwise coded 0.

X_6 = Shelled corn storage capacity on the farm, measured in hundreds of bushels.

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[3] Economic rationale for the relationships of these explanatory variables to the purchasing decision is explained in detail in a previous study by Hill [11].

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X_7 = percent of total corn production sold at harvest.

X_8 = Age of the farm operator grouped as 1 = under 25 years; 2 = 25–34; 3 = 35–44; 4 = 45–54; 5 = 55–64; 6 = 65 and over.

X_9 = Elevator drying charges in cents per bushel per point of moisture removed.

X_{10} = A composite of several measures of the adequacy of elevator services recorded on a scale from 0 to 21.

Y^o_i = the ownership of a grain dryer by the ith farmer.

Y^p_i = the purchase of a grain dryer by the ith farmer in a given year or period.

Y^i_i = the intentions of the ith farmer to purchase a grain dryer within a 3-year period.

Decision to purchase a dryer would ordinarily precede actual installation by several days or weeks, and the stimuli prompting the decision could precede installation by several months or years. A time dimension is therefore an important factor in the model, varying in degree with the explanatory variable under consideration. Many of the variables in the model, such as farm size, may reach the threshold level one or more years prior to actual installation of the dryer. This would be due to the advance planning required for a grain-handling system and to interrelationships between dryer ownership and the necessary harvesting, handling, and farmstead equipment. In the statistical estimation of the effect of these variables on the decision, observation of the dependent variable should lag behind observation of the explanatory variables.

On the other hand, the effect of a variable such as age of operator exerts its influence on responsiveness to stimuli at the time the decision is made and need not be lagged.

A third group of variables is simultaneously determined, and the cause-effect relationship is difficult to isolate in a statistical model. For example, the percent of shelled corn to sell at harvest must be decided in conjunction with the availability of drying capacity and causality flows both directions.

Three basic models were employed in this study. The first model examined present ownership of a dryer and related it to present farm characteristics such as size, percent field shelled, land ownership, etc. This model does not show pure causality, because present farm characteristics may be quite different from characteristics at the time the dryer was purchased.

The second type of model focused on causality by identifying the year in which the dryer was purchased and relating the purchase to farm characteristics of the same or previous years. For example, a dryer purchased in 1970 was related to farm size in 1967. The actual number of years that each variable was lagged was determined by economic logic and by experimentation with different equations and time periods.

A third type of model was used to explain the decision process by analyzing the farmer's indicated intention to purchase a dryer within the next three years. In 1967 each farmer was asked if he intended to purchase new or additional drying equipment within the next three years. The answers were then checked against reported purchases in 1968, 1969, and 1970, and the relationship between intentions and actual purchases was analyzed.

Data used to test these economic relationships were obtained from a panel of Illinois farmers maintained by the Farm Research Institute of Urbana, Illinois. Data on dryer ownership and farm characteristics were available from 1967 panel responses; similar data were obtained for 1970.

Empirical Results

Results of the three types of models described above are summarized in Table 1. Most of the signs of the coefficients are consistent with hypothesized relationships, and the tests of significance help to indicate their importance in explaining the purchasing decisions of farmers. The probability that a particular farmer will purchase a grain dryer can be calculated from the coefficients shown in Table 1 as follows: Calculate the value of $\hat{A}_i$ by inserting the appropriate values of X_i in the equation $\hat{A}_i = B_1X_1 + B_2X_2 + \cdots + B_mX_m$. The probit-probability transformation table[4] can be used to transform values of $\hat{A}_i$ into probability.

The equation and coefficients can also be used to estimate the percent of farmers in a particular class or geographical area who pres-

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[4] The symbol A is equivalent to the term "probits" in the traditional probit analysis in which A^* is assumed to be $N(5, 1)$. See [7].

Table 1. Probit estimates from equations analyzing ownership, purchases, and intentions to purchase grain dryers by Illinois farmers

Variables	Models					
	I[a]	II[a]			II A[b]	III[c]
	Equation 1	Equation 2	Equation 3	Equation 4	Equation 5	Equation 6
1 Constant Term	−1.823**[d]	−1.28**	−2.34**	−1.28*	−2.59**	−.79
2 Farm Size	.0023**	.0007	.001	.004**	.0003**	.002**
3 Farm Type	.828**	.07	−6.55	.617	.476	.284
4 Percent Field Shelled	.0215**	.007**	.002	− .006	.0099**	.003
5 Tenancy	− .128	.12	.893*	− .456	—	−.33
6 Shelled Corn Storage	—	—	—	—	—	.0006
7 Percent Sold at Harvest	− .0136**	− .01*	.004	.002	—	.003
8 Operator's Age	− .143*	− .169	− .153	− .166	− .058	−.253**
9 Elevator Drying Charges	—	—	—	—	—	—
10 Adequacy of Elevator Service	—	—	—	—	—	—
11 Dryer Ownership in 1967	—	—	—	—	2.63**	.135
12 Change in Percent Field Shelled	—	—	—	—	.009**	—
13 1967 Intent To Purchase	—	—	—	—	.816**	—
14 Dependent Variable[e]	Y^O_{70}	Y^P_{68}	Y^P_{69}	Y^P_{70}	Y^P_{68-70}	Y^I_{70}

[a] Observations on the explanatory variables for these equations were reported for 1967.

[b] The variables of farm size, dryer ownership, and intentions used 1967 data; the other explanatory variables contained 1970 data.

[c] Observations on the explanatory variables for equation 6 were reported for 1970.

[d] ** indicates the coefficient is significant at the 1 percent level; * indicates significance at the 5 percent level.

[e] The dependent variables are identified as follows: the three variables of dryer ownership, purchases of a dryer, and intentions to purchase a dryer are represented by the superscripts of O, P, and I, respectively. The numerical subscripts identify the year or years for which observations on the variable were obtained.

ently own a dryer. Mean values for each independent variable are substituted in the equation to calculate $\hat{A}_i$ for the class or region. The probit-probability table is used to obtain percentages. When predicting ownership for a particular geographical region, it may be preferable to stratify potential customers according to major explanatory variables (e.g., hog farmers, owner-operator, etc.). This is particularly helpful if there is evidence that the population is not normally distributed over the independent variables. The percent of farmers owning dryers can then be predicted for each class strata, or the class estimates may be aggregated for a region. The estimated number of farmers owning dryers can be compared with actual numbers as reported by the U. S. Census of Agriculture to obtain a measure of sales potential.

The estimation procedure for probit results in theoretical values of A_i that lie between $-\infty$ and $+\infty$ with mean zero and variance 1. Estimates of the parameters for a given population at different points in time may show differences in farmers' reaction responses as reflected in different values of $\hat{B}_i$. Distribution of $\hat{A}_i$ will remain unchanged as will the average threshold value for the population. Although the mean and variance of $\hat{A}_i$ is the same for any normally distributed population, differences can be identified by calculating values $\hat{A}$ and $\hat{A}^*$ for particular classes within the population. This is illustrated by calculating $\hat{A}_i$ for all respondents owning a dryer in the 1970 survey and comparing their mean and variance with those respondents not owning a dryer. The mean and variance of $\hat{A}_i$ were .41 and .62, respectively, for $Y=1$. For farmers not owning dryers mean and variance were -1.11 and 1.0. Overlap of the two tails of the distribution one standard deviation from the means included values from $-.38$ to $-.11$, suggesting a value of A_i^* within this range for most of the respondents. The distribution for $Y=1$ was skewed to the right from using dryer ownership at one point in time as the dependent variable, even though the actual purchase may have been made several years previously. Changes in variables, for example increased farm size, can be used to predict the movement of A_i since purchase of the dryer would tend to move the value of $\hat{A}_i$ to the right of the true value of a farmer's A_i^*.

The effect of changes in the independent variables on the probability of dryer ownership cannot be interpreted directly from the coefficients of Table 1 as is commonly done for regression. Referring to the final equation derived under the probit model, $E(Y_i|A_i)=F(A_i)=F(B_1X_{1i}+B_2X_{2i}+\cdots\cdots+B_mX_{mi})$, it is evident that given a change in the values for any X_i, magnitude of $\hat{B}_i$ determines the change in value of the index for the ith farmer ($\hat{A}_i$). The effect of this change in $\hat{A}_i$ on the probability of dryer ownership is determined through the normal cumulative function discussed previously.

Analysis of intentions and incorporation of a time dimension in the models summarized in Table 1 provide a basis for interpreting relationships between the individual explanatory variables and the decision process of farmers, permitting improved estimation of future purchases of grain dryers.

Percent of corn field shelled

Given the bushels of corn harvested, the percent of corn field shelled is a measure of the volume of high moisture corn that will require drying before it can be safely stored. It is therefore a significant variable in explaining present dryer ownership (Model I) and actual purchase of a dryer (Model IIA). Since the actual change between 1967 and 1970 in the percent of corn field shelled was assumed to be a result of a planned decision anticipated in 1967, the actual purchase of a dryer between 1968–70 should be a function of the change in field shelling. Statistical analysis of Model IIA supports this hypothesis with significant coefficients for both percent of corn field shelled and change in the percent of corn field shelled.

However, no significant lag was evident in this variable, and the coefficients were not statistically significant when the dependent variable was lagged more than one year (equations 2, 3, and 4). Since field shelling creates the immediate problem of disposing of high moisture corn, the two decisions must be closely coordinated.

Although the percent of corn field shelled was a significant variable in explaining 1967 intentions to purchase in a previous study [17], it was not significant in the 1970 intentions model (Model III). Those farmers for whom field shelling is an economic alternative are rapidly approaching 100 percent field shelled harvesting. Other farmers harvesting only ear corn may be unresponsive to the overall trend. For these reasons, field shelling is diminishing in importance in explaining the intentions to purchase a dryer.

Size of corn enterprise

Economies of scale suggest that some minimum size of corn volume is necessary to justify purchasing a farm dryer. This minimum varies with other characteristics of the farm and the operator, but it is a basic factor in explaining dryer ownership as indicated by Model I. In terms of causality there appears to be a strong lag effect, and the size of the coefficient and the significance level increased as the time span between farm size and year of purchase was increased (equations 2, 3, and 4). Intentions to purchase are also influenced by farm size as shown by the significant coefficient in Model III.

Age and education

Both age and education are important variables in the decision process. Due to the high correlation between these two variables, only age was entered in the equations reported here. Younger farmers tend to be more flexible in their decisions, adopt new ideas and technologies more readily, and due to expected life span will anticipate a longer pay-out period for investments. Importance of this variable is its effect upon attitudes of individuals. It is therefore influential only at the point of decision. It was a significant variable in equations where dryer ownership or intentions to purchase was the dependent variable, but there was no observable lag effect.

Type of farm

The best relationship between farm type and dryer ownership was obtained using a 0–1 variable where all farms having more than 500 hogs were coded 1 and all other farms were coded 0. This was a measure of the dry shelled corn required for feeding. While this variable was significant in explaining present ownership of a dryer (Model I), it was not significant in explaining purchases since 1968, regardless of the time lag introduced. This variable was not significant in either the 1967 or 1970 intentions equations. This may be partially explained by the relative stability of farm type during the three-year period—only 13 of the 571 farms changed from the "0" category to the "1" category between 1967 and 1970.

Storage capacity for shelled corn

The cause and effect relationship between on-farm shelled corn storage capacity and the purchase of a dryer was not clear on *a priori* grounds. There are several explanations for the high correlation between drying and storage capacity, all equally consistent with economic logic: (1) Ownership of a dryer encourages the purchase of storage capacity to avoid elevator delivery and/or sale at harvest; (2) Existing on-farm storage for shelled corn has only limited value without some means of moisture reduction at harvest; (3) Drying and storage capacity are purchased simultaneously. Bin-type dryers (accounting for more than 80 percent of all farm dryers in Illinois) provide both drying and storage capacity in a single unit.

A number of different formulations of the model (not shown) were used to test consistency of the data with the above hypotheses. The simultaneity explanation was weakened by the fact that 53 percent of the farmers owning shelled corn storage did not own dryers. Although storage capacity was a significant variable in explaining dryer ownership, neither the size of the coefficient nor the level of significance was increased by lagging the date of dryer purchase relative to storage capacity. The intentions model also failed to support the causality hypothesis as indicated by a lack of significance in all the intentions equations. It can be concluded that shelled corn storage exists independently of drying capacity. It is often purchased simultaneously with a dryer, but it is not a determining factor in the actual decision to purchase.

Due to the high intercorrelation with other variables and the problem of joint decisions, storage was not included as a variable in most of the equations in Table 1.

Tenancy

Based on previous work [11], it was thought that security of an owned home base and elimination of the landlord problems in sharing costs of drying and storage would result in a positive relationship between land ownership and dryer ownership. Although the sign of the coefficients for this variable was consistent with the hypothesis, the level of significance for the variable was quite low in nearly all equations. Neither tenancy nor change in tenancy was significant in the intentions model; thus, this variable must be relegated to a very minor role in explaining the decision to purchase a dryer. Had it been possible to measure the landlord's attitude toward sharing the cost of drying and storage, this might have been a significant variable.

Percent of corn sold at harvest

The intended use or disposition of wet shelled corn is a basic factor in designing the harvesting-handling system. If the grain is to be sold at harvest, no storage capacity is needed and on-farm drying is not likely to be feasible. Grain that is to be fed or stored for later sale may be dried on- or off-farm. The decision to sell a high proportion of production at harvest is thus closely tied to the drying decision; but it may be considered as either a cause or an effect.

Model I shows that the percent of corn sold at harvest in 1967 is significantly correlated with dryer purchases in or before 1970. Model II (equations 2, 3, and 4) shows the significance level decreasing as the variable is lagged. When both storage capacity and percent sold at harvest were included as variables, percent sold was no longer significant, indicating that on-farm storage and sales at harvest are opposite sides of the same coin. The variable was not significant in explaining intentions to purchase (equation 6).

In summary, the percent of corn sold at harvest appears to be highly correlated with the drying-storage decision but is not an explanatory factor in the decision.

Drying charges at the elevator

Since drying corn at the elevator is a close substitute for on-farm drying, economic logic would suggest that changes in the price of one (i.e., elevator drying charges) would affect the quantity of the other (i.e., the use of farm dryers). Although a previous study [12] indicated a relationship between on-farm drying and charges in 1967, no significant relationships between these variables could be established with the 1970 data from the Farm Research Institute. Several factors may have been responsible for the lack of significance. (1) Data on drying charges were available only for 1970 from the Farm Research Institute Panel, and it was therefore not possible to lag the purchasing decision behind the price stimulus. (2) Less than 26 percent of the 1970 respondents were able to provide information on drying charges. (3) Competitive pressures among elevators have resulted in a tendency toward lowering the drying charges over the past few years, thus creating a favorable image of "fair and reasonable" charges among farmers. (4) At their present level, drying charges are not an important factor in the farmer's decision to purchase a dryer. On-farm costs are quite comparable with elevator charges, and the factors of farm size, operator's age, percent field shelled, etc., are the primary bases for the decision. This is further supported by respondents' answers to the question, "If you now own a dryer, what factors were important in the decision to purchase?" Thirty-four percent said convenience, compared to 12 percent who reported that drying charges influenced their decision. These results suggest the relegation of "price" to a minor role in the decision process.

Adequacy of elevator services

Questions intended to measure respondents' evaluation of the adequacy of elevator services were combined into an index. This variable was significant at the 85 percent level (not shown). The short corn crop of 1970 may have biased the responses in favor of the elevator, but the data available only weakly support the hypothesis that adequacy of services is influential in the decision to purchase a dryer.

Previous dryer ownership

In a previous study a positive correlation between dryer ownership in 1967 and intentions to purchase a dryer during the next three years suggested that expansion of capacity is an important source of new dryer sales [17]. The 1970 data do not support the same conclusion because present ownership is no longer a significant variable (equation 6). The most significant difference between these two years is size of the crop. One may hypothesize that because of the 1970 corn blight and associated low production, farmers were anticipating a small crop for 1971 and at the time of the survey of panelists (January 1971) saw no need for expanding drying capacity. This explanation leaves the basic conclusion unchanged—i.e., expansion of drying capacity is the primary source of sales—while accounting for the observed reaction of the respondents in the 1970 survey. If this conclusion is correct, then 1971 purchases and intentions to purchase should again be higher among those farmers presently owning dryers.

Intentions to purchase

Purchase intentions are no guarantee of a sale because many of the farmers who report plans to purchase never complete the transaction. One way to evaluate the significance of the intentions to purchase as reported by farmers is to include the 1967 statement of intentions as a variable in the 1968–70 purchases equation (Model IIA). Results show that intentions were a significant variable in explaining actual purchases during the indicated period.

Summary and Implications

Models presented in this study provide a basis for estimating potential sales of grain dryers to farmers. The threshold concept permits explanation of the relationship between changing farm characteristics and dryer purchases. Incorporation of a time dimension in the analysis helped identify size of enterprise as the most significant causal variable in the decision process. Other significant variables in the statistical analysis were joint or concurrent decisions which the farmer must make at the time he changes his harvesting and marketing system.

Statistical properties, theoretical relationships, and the empirical application described in this paper demonstrate appropriateness of the multivariate probit model for problems where the dependent variable is dichotomous and where the decision process involves a threshold effect. The threshold concept is basic in the understanding of many economic problems involving purchasing decisions, and the probit technique permits quantification of the relationship between a threshold decision and the explanatory variables.

References

[1] Berkson, J., "The Application of the Logistic Function to Bio-Assay," *J. Am. Stat. Assoc.* 39:357-365, 1944.

[2] Berry, Brian J. L., *Geography of Market Centers and Retail Distribution*, Englewood-Cliffs, New Jersey, Prentice-Hall, Inc., 1967.

[3] Bilkey, Warren J., *The Basic Relationship in Consumer Expenditure Behavior*, Cambridge, Harvard Studies in Marketing Farm Products No. 4-H, 1951, p. 66.

[4] Brennan, J. F., "Evaluation of Parameters in the Gompertz and Makeham Equations," *J. Am. Stat. Assoc.* 44:116–121, 1949.

[5] Dagenais, Marcel G., "A Threshold Regression Model," *Econometrica* 37:193–203, April 1969.

[6] Farrell, M. J., "The Demand for Motor Cars in the United States," *J. Royal Stat. Soc.* 117:171–201, 1954.

[7] Finney, D. J., *Probit Analysis*, Cambridge, England, Cambridge University Press, 1952.

[8] Goldberger, Arthur S., *Econometric Theory*, New York, John Wiley and Sons, Inc., 1964.

[9] Hallberg, M. C., "Projecting the Size Distribution of

Agricultural Firms—An Application of a Markov Process with Non-Stationary Transition Probabilities," *Am. J. Agr. Econ.* 51:289–302, May 1969.

[10] HECKEL, R. V., and R. M. JORDAN, *Psychology*, St. Louis, The C. V. Mosby Company, 1967.

[11] HILL, L. D., "Economic Determinants of the Farm and Elevator Trends in the Volume of Corn Artificially Dried," *Am. J. Agr. Econ.* 52:555–568, Nov. 1970.

[12] ———, "Relationship of Elevator Charges to Off-Farm Drying of Corn," *Ill. Agr. Econ.* 10:8–14, Jan. 1970.

[13] ———, "Use of Weighted Regression in Estimating Models of Binary Choice," *Canadian J. Agr. Econ.* 18:64–72, Nov. 1970.

[14] ISAACSON, R. L., M. L. HUTT, AND M. L. BLUM, *Psychology: The Science of Behavior*, New York, Harper and Row Publishers, 1965.

[15] JOHNSON, G. L., A. N. HALTER, H. R. JENSEN, AND D. W. THOMAS, *A Study of Managerial Processes of Midwestern Farmers*, Ames, Iowa State University Press, 1961.

[16] JOHNSTON, J., *Econometric Methods*, New York, McGraw-Hill Book Company, Inc., 1963.

[17] KAU, PAUL K., "A Threshold Model of the Grain Dryer Purchasing Decisions of Illinois Farmers," unpublished Ph.D. thesis, University of Illinois, Feb. 1971.

[18] KNIGHT, FRANK H., *Risk, Uncertainty and Profit*, New York, Harper and Row Publishers, 1965.

[19] LEE, T. C., "Estimation of Regression Parameters with the Predicted Dependent Variable Restricted in a Certain Range: Comment," *Am. J. Agr. Econ.* 52: 613–614, Nov. 1970.

[20] NEWMAN, J. W., AND R. STAELIN, "Multivariate Analysis of Differences in Buyer Decision Time," *J. Marketing Res.* 8:192–198, May 1971.

[21] NOURSE, H. L., *Regional Economics*, New York, McGraw-Hill Book Company, 1968.

[22] ROSETT, R. N., "A Statistical Model of Friction in Economics," *Econometrica* 27:263–267, April 1959.

[23] SIMON, H. A., "Theories of Decision-Making Economics and Behavioral Sciences," *Amer. Econ. Rev.* 49:253–281, June 1959.

[24] TOBIN, JAMES, "The Application of Multivariate Probit Analysis to Economic Survey Data," Cowles Foundation Discussion Paper No. 1, 1955.

[25] ———, "Estimation of Relationships for Limited Dependent Variable," *Econometrica* 26:24–36, Jan. 1958.

[26] TOMEK, W. G., "Regression Analysis with a Limited Dependent Variable," *J. Farm Econ.* 50:445–447, May 1968.

[27] YAMANE, TARO, *Statistics, An Introductory Analysis*, 2nd ed., New York, Harper and Row Publishers, 1960.

[28] ZELLNER, A., AND TONG-HUNG LEE, "Joint Estimation of Relationships Involving Discrete Random Variables," *Econometrica* 33:382–394, April 1965.

The Process of an Innovation Cycle*

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An economic theory of the process of diffusion of innovations is developed and illustrated. In the theory, adoption is determined by comparative advantage considerations. An innovation is first adopted by skilled and experimenting entrepreneurs and then "diffuses" down the skills scale. If the innovation affects supply substantially, prices may decline, profits eliminated, and early, skilled (and high labor opportunity cost) producers may exit from the affected line of production—hence, an "innovation cycle." The theory implies that technological change is affected by the distribution as well as by the average level of skills.

ONE would expect comparative advantage considerations—dynamic as well as static—to be crucial in determining patterns of adoption of innovations. This has been recognized in empirical work by, for example, Griliches [2], Mansfield [6] and Nelson [8] who incorporated measures of such items as benefits, costs, and profits as explanatory variables in the analysis. The most explicit recognition of the role of comparative advantages in the adoption of innovations is found in the theory of the "product cycle" in international trade as expounded by Vernon [12] and Hufbauer [3]. The present study is an analysis of a similar process within one industry. A formal model describing an "innovation cycle" is developed in the first part of the paper and illustrated by an example from agriculture in the second.

The model concentrates on the main aspects of the analysis and is based on simplifying assumptions. It is assumed that the innovation is either a new product or a new method that appreciably affects the supply of an existing product. The industry is competitive and is composed of small firms. Producers with the highest skills (the better schooled, perhaps) will be first to adopt the innovation. Their advantage is in spotting a good idea, experimenting with it, and solving problems of adaptation to local conditions. As industry's experience accumulates, others adopt. The increasing supply reduces price. This will drive the first adopters (the highly skilled and high labor opportunity cost producers) out of the production of the new product—hence, an "innovation cycle."

A major implication of the model is that skills are more important the more dynamic the economy. This notion is also developed by Nelson and Phelps [10] and Welch [13], who distinguishes between the "worker effect" (increasing production from an existing bundle of inputs) and the "allocative effect" of schooling (improving the allocation of inputs and outputs). Welch argues that in a technologically stagnant economy experience will lead to optimal allocation in all firms and that schooling's economic contribution will be limited to the worker effect.

In the innovation cycle model the allocation problem is timing the adoption of the innovation, but there is a slight difference between Welch's formulation and that of the authors. In his analysis, lesser-schooled producers simply make allocation errors; in this analysis, they know (or estimate) their lower efficiency in production. In this respect the present model is in line with the traditional economic approach of perfect knowledge and equilibrium: producers act rationally, being aware of their abilities, and firms are always in equilibrium (not necessarily static), while the other diffusion models that have been proposed assume, explicitly or implicitly, disequilibrium and lags in adoption originating from lack of realization on the part of the producers of potential benefits in new factors or products.[1]

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[1] These distinctions are not essential to the model. One could derive the same results on the assumption that lower skilled producers are as efficient as others in production but unaware of opportunities. The policy implications (in terms of the direction of extension work, for example) are quite different. See also [9, p. 102] for evidence that nonadopters are aware of innovations.

Specification

The model consists of three building blocks: the firm, the product, and the industry. For the sake of exposition it is assumed that technology is stagnant apart from the introduction of the innovation.

The firm is defined by an initial endowment of the entrepreneur's own labor, L_i in firm i, and skills, E_i. All other factors are bought freely on the market; the industry is competitive, and firms do not have monopoly or monopsony power. The firm produces several products and complementarity between skills and other factors of production is assumed; thus, the shadow price (opportunity cost), w_i, of the entrepreneur's own labor (a joint input of "raw labor" and skills) is an increasing function of his skills:

$$w_i = w(E_i) \qquad w'_i > 0. \tag{1}$$

The product q is produced by own labor, L (measured in labor units), and by other factors (including land and capital), v (in dollars), in a production function in which a knowledge component, a function g, enters in a multiplicative form (Hicks-neutrality is assumed):

$$q = f(L, v)g. \tag{2}$$

The knowledge factor is a function of skills and the Arrow-type learning by doing [1]. Learning is proportional to the experience at the industry level,[1] H,

$$H(t) = \int_0^t Q(s)ds \tag{3}$$

where Q is the total industry output of the new product, and time is measured from the introduction of the innovation.

Since w is a one-to-one function of E, it will be convenient to substitute w for E and write the knowledge function as

$$g = g(w, H), \tag{4}$$

with the following restrictions:

$$0 \leq g \leq 1$$

$$\frac{\partial g}{\partial w} \geq 0, \frac{\partial^2 g}{\partial w^2} \leq 0$$

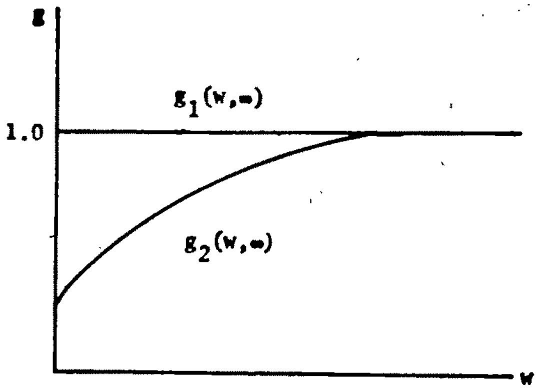

Figure 1. Knowledge functions with maximal experience

$$\frac{\partial g}{\partial H} > 0, \frac{\partial^2 g}{\partial H^2} < 0$$

$$\lim_{H\to\infty} \frac{\partial g}{\partial H} = 0.$$

With these restrictions, equation (2) is a two-stage production function. In the first stage, skills and experience are combined in a "well-behaved" production function to create a knowledge component that is combined in the second stage with the physical process to produce the final product.

This specification is not limited to the new product under consideration; other products were also new in the near or remote past. Write $g(w, \infty)$ for knowledge with maximal amount of learning. Two general classes of products can be distinguished (Fig. 1). In the first class (perhaps wheat growing), $g_1(w, \infty) = 1$. Given enough experience, all producers will possess the same level of knowledge specific to the production of this product. Here experience can completely substitute previously acquired skills. In the second class (radio manufacturing, say), $g_2(w, \infty) < 1$ for some range of w. Here a "worker effect" exists in the production of the product. The assumption of complementarity between skills and other factors in a technologically stagnant economy, introduced earlier, implies existence of a "worker effect" in at least some of the firm's products.

The industry is competitive but faces a downward sloping demand curve for the new product with the price

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[1] Whether experience at the industry level is relevant for the individual's knowledge function depends on the industry's organization. In modern agriculture, with strong public and commercial extension service, industry's experience is probably more important than the individual producer's.

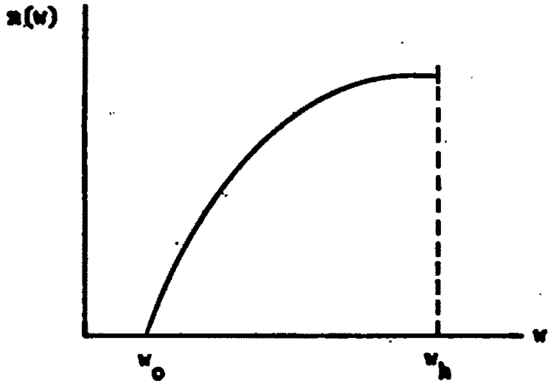

Figure 2. Accumulated distribution of producers

$$P = P(Q) \tag{5}$$
$$P' < 0.$$

Producers in the industry can be ordered by skills (shadow price of own labor). Let $n(w)$ be the number of producers with shadow price w or less. Cumulative function n is nondecreasing; assume it to be differentiable (Fig. 2). If w_o is the lowest in the industry and w_h the highest, then $n(w_o)=0$, and $n(w_h)$ is the total number of producers in the industry. The function $n'(w)$ $(\equiv dn/dw)$ is the frequency distribution of producers. The particular form depicted in Figures 2 and 4, in which n' is diminishing with w, implies greater concentration of producers in the lower skill range.

Profits and Final Distributions

Generally, producers will adopt the new product if it is profitable and will increase production if profits increase. But to focus on the essentials and to reduce mathematical complexity, assume that a new product is produced in all firms by identical and fixed amounts $\hat{L}$ $\hat{v}$ of physical inputs. Let

$$\hat{q} = f(\hat{L}, \hat{v})\cdot 1$$

be the output of a firm for which $g(w, H)=1$, that is, a firm with maximum knowledge. Assume further that introduction of the new product does not alter w, the shadow price in the other lines of activity in the firm; then profits above alternative costs in the new product in firm i are

$$\pi_i = P\hat{q}g(w_i, H) - w_i\hat{L} - \hat{v}. \tag{6}$$

The firm will produce only if profits are positive:

$$q_i = \hat{q}g(w_i, H) \qquad \pi_i > 0$$
$$q_i = 0 \qquad \pi_i \leq 0.$$

With this study's assumptions profits will increase with w for low levels of the shadow price and decrease for higher levels (Fig. 3). Let $\underline{u}$ and $\bar{u}$ be the lowest and the highest w values for which $\pi(w)=0$. [When the diffusion process starts, profits are positive for the highest skilled operators; therefore, set $\bar{u}=w_h$ if $\pi(w)=0$ for $w>w_h$. Similarly, set $\underline{u}=w_o$ if $\pi(w)=0$ for $w<w_o$.] Production will take place by producers with shadow prices on the range $(\underline{u}, \bar{u})$. With time, experience accumulates, production expands, and prices fall. In the innovation cycle process, falling prices drive highly skilled (and wage) producers out, while low-skilled producers benefit from experience and adopt the innovation.

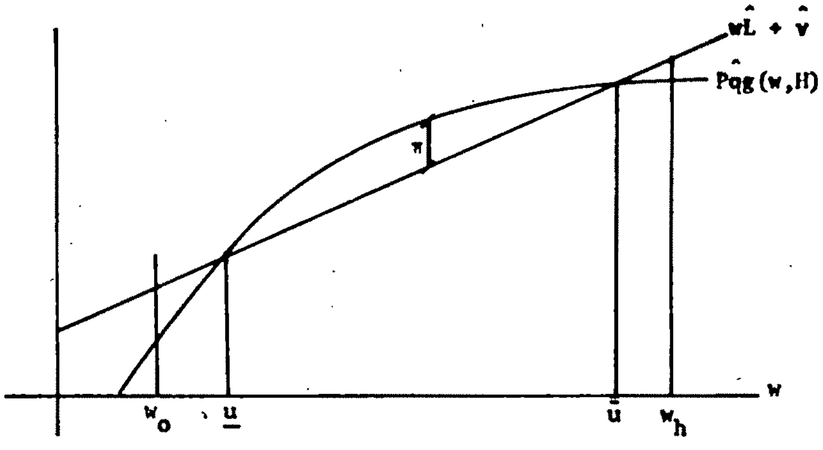

Figure 3. Revenue, costs and profits

To trace the innovation cycle, focus on the movement of the boundaries, the break-even points $\underline{u}$, $\bar{u}$. For these points $\pi=0$ always. Differentiating equation (6) with respect to time, incorporating $\dot{\pi}(\equiv d\pi/dt)=0$ and writing $\partial g/\partial u$ for $\partial g/\partial w$ evaluated at u,

$$\dot{u} = \frac{P'\dot{Q}\hat{q}g(u, H) + P\hat{q}\dfrac{\partial g}{\partial H}Q}{L - P\hat{q}\dfrac{\partial g}{\partial u}} \tag{7}$$

$$(u = \underline{u}, \text{ or } u = \bar{u}).$$

In other words, for $\underline{u}$ and $\bar{u}$,

$$\dot{u} = \frac{\text{market effect} + \text{learning effect}}{-\dfrac{\partial \pi}{\partial u}}.$$

For $\bar{u}$, the (negative) market effect is stronger than the (positive) learning effect and $\partial\pi/\partial u<0$, thus $\dot{\bar{u}}<0$. With a learning effect stronger than market effect and $\partial\pi/\partial\underline{u}>0$ (Fig. 3), $\dot{\underline{u}}<0$ also. At the beginning of the diffusion process, $\bar{u}=w_h$ and $\dot{\bar{u}}=0$ until highly skilled producers begin to exit.[3]

The innovation cycle may continue until $\underline{u}=w_o$, but this is not the only possibility. Several alternative *final* distributions of producers (attained after the completion of the diffusion process) can be distinguished. Four such cases are depicted in Figure 4. Case (c) is an innovation cycle as described above. In case (a) the demand is highly elastic and skilled producers did not exit at all. In cases (b) and (d) the innovation cycle stopped at $\underline{u}>w_o$. A necessary condition for this is the existence of a worker effect $[g(w,\infty)<1]$ in the new product, so that low-skilled producers can never, not even with maximal industry experience, master the profitable production of this product.

Further Dynamics

Total product of the industry is

$$Q = \int_{\underline{u}}^{\bar{u}} n'(w)\hat{q}g(w, H)\, dw. \tag{8}$$

Taking a time derivative of Q, incorporating (7), and making use of $\dot{H}=Q$, one obtains:

$$\frac{\dot{Q}}{Q} = \phi(Q, H) = \tag{9}$$

$$\frac{\left(\hat{q}\displaystyle\int_{\underline{u}}^{\bar{u}} n'(w)\frac{\partial g}{\partial H}\,dw + P\hat{q}^2\right.}{1 - P'\hat{q}^2\left[\dfrac{n'(\bar{u})g(\bar{u}, H)^2}{-\dfrac{\partial\pi}{\partial\bar{u}}} - \dfrac{n'(\underline{u})g(\underline{u}, H)^2}{-\dfrac{\partial\pi}{\partial\underline{u}}}\right]}$$

$$\left.\cdot\left[\frac{n'(\bar{u})g(\bar{u}, H)\dfrac{\partial g}{\partial H}}{-\dfrac{\partial\pi}{\partial\bar{u}}} - \frac{n'(\underline{u})g(\underline{u}, H)\dfrac{\partial g}{\partial H}}{-\dfrac{\partial\pi}{\partial\underline{u}}}\right]\right)$$

It can be shown that $\phi(Q, H)\geq 0$. The solution to (9) is

$$Q(t) = \exp\left[\int_0^t \phi(Q, H)ds + c\right] \tag{10}$$

with

$$Q(0) = \exp(c).$$

Equation (9) in its present form is applicable when the innovation cycle proceeds with producers entering and others dropping the production of the new product. At the beginning of the process, before the exit of the skilled producers, or always in cases (a) and (b) in Figure 4, $\bar{u}=w_h$ in the integral in equation (9) and other terms involving $\dot{\bar{u}}$ vanish (since $\dot{w}_h=0$). When $\underline{u}=w_o$ in case (a), or in all other cases when movement of producers in or out stops, Q will continue to grow as a result of learning at the rate

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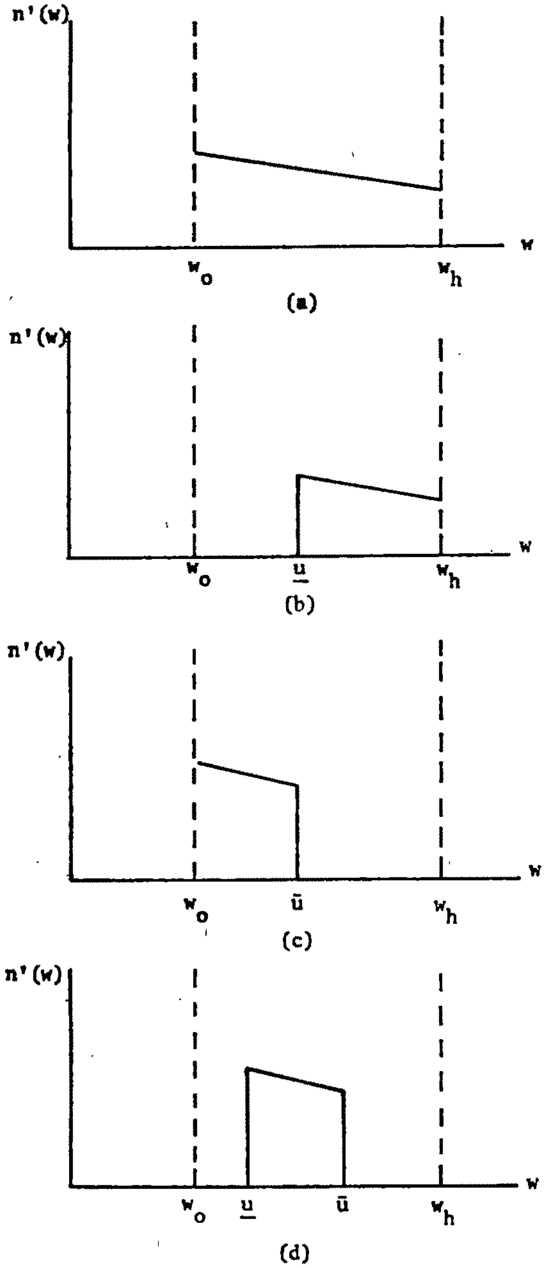
[3] For the innovation cycle proper to exist, that is, for the innovation to move from highly skilled producers who drop it to low skilled ones who adopt it, the market effect at $\bar{u}$ has to be stronger than the learning effect. If this is not the case, highly skilled producers will never drop the new product. These alternative possibilities will be reflected in different final distributions as exemplified in the next section in the text.



(a)

(b)

(c)

(d)

Figure 4. Final distribution of producers [with $g(w, \infty)$]

$$(9.1) \qquad \frac{\dot{Q}}{Q} = \hat{q} \int_{\underline{u}}^{\bar{u}} n'(w) \frac{\partial g}{\partial H} dw$$

until $\partial g/\partial H$ vanishes. [$\dot{Q}$ can be expected to have discontinuities and Q "kinks" where producers start or stop to exit; and, strictly speaking, the integral in equation (10) is calculated between such discontinuities.]

Unlike other diffusion models proposed [6, 8], the present one does not yield a logistic time pattern. In some cases, however, an S-shaped function can be expected. In all, $\dot{Q}$ will eventually approach zero as time passes and $\partial g/\partial H \rightarrow 0$ for all levels of w. When the process starts, P' will in many cases be comparatively low due to shifts in short-run demand associated with the market's growing familiarity with the new product, and $\dot{Q}$ can be expected to grow approximately in proportion to Q (particularly so long as $\bar{u} = w_h$). These two effects, at the beginning and the end of the process, may be expected to generate an S-shaped time pattern of production.

If production of the new product can be expected to taper off asymptotically as experience accumulates, this will not be the general rule with respect to the number of producers, particularly not in cases (a) and (c). Let the number of producers be N,

$$(11) \qquad N = n(\bar{u}) - n(\underline{u}).$$

Then

$$(12) \qquad \dot{N} = n'(\bar{u})\dot{\bar{u}} - n'(\underline{u})\dot{\underline{u}}.$$

In cases (a) and (b) in Figure 4

$$(13) \quad \dot{N} = -\frac{n'(\underline{u})}{\dfrac{\partial \pi}{\partial \underline{u}}} \left[P'\dot{Q}qg(\underline{u}, H) + Pq \frac{\partial g}{\partial H} Q \right].$$

$\dot{N}$ is positive since the learning effect is stronger than the market effect (see equation 7). But $\dot{N}$ can actually *increase* as $\underline{u} \rightarrow w_0$ if $n'(w)$ is high for low values of w (this is the assumption in Figures 2 and 4), reflecting higher concentration of producers in the lower skilled groups. One could expect a general sigmoidal form of N in time in cases (b) and (d) with entry rates increasing at the beginning of the process and then starting to decline as the skilled producers exit, not necessarily converging asymptotically to zero.

On theoretical grounds these results are inconsistent with the common observations that fit nicely logistic time patterns. The reason may be in the neglect in the present model of the imitation component [6], which is a factor that associates the rate of adoption with the ratio of the number of potential adopters to those who had already adopted. This implies that the diffusion process is affected by the intensity of interactions between these two

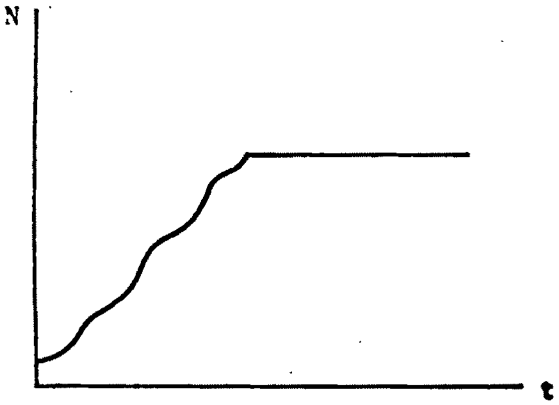


Figure 5. **Possible time pattern of N**

groups.[4] But on practical grounds, this inconsistency should not be exaggerated. With errors in observations and in the behavior of producers (who make their decisions according to next season's expected prices) the judgment between the alternative models is not easy. Observations generated by a theoretical time pattern as in Figure 5 can look rather consistent with a logistic function, and in empirical work such a function can be the most suitable for summarizing the diffusion information. (This is the approach followed in the application below.)

Remarks

Profits made by the first adopters of a new product can justifiably be regarded as rent to innovativeness. Whether the final producers of the new product will enjoy higher incomes in the long run depends on the cross elasticity of demand between the new product and other products of the industry, and (relaxing the assumption of a fixed number of producers) on the elasticity of supply of similarly skilled producers who may be lured into the industry by persistent profits. If these two factors are unimportant, introduction of the new product will increase profits in the long as well as in the short run. (If inputs are not fixed, introduction of the new product will alter shadow prices, profits in competitive equilibrium will vanish, but incomes can be higher than before introduction of the innovation.)

The boundary between rent to innovativeness and additional income to noninnovating latecomers is not clear cut. But, it is worth reemphasizing that the returns to highly skilled producers from early adoption are over and above what they earn in other lines of production. These returns are transitory; to maintain them, skilled producers have to search continuously for new ideas and products.

From the social point of view, rent to innovativeness is a payment for skills (investment in schooling and training), for efforts in adaptation, and for risk-taking. The last elements do not appear explicitly in the model. The innovation cycle raises interesting welfare issues. (Should optimal *level* of schooling be a policy goal or should it be optimal *distribution* of human capital?) But these are also outside the scope of the present paper.

An Illustration[5]

The model is illustrated with diffusion of an innovation in agriculture in Israel. The innovation is the technique of growing winter vegetables (tomatoes, cucumbers, peppers—which had been in limited supply) under plastic covers. Protective tunnels constructed from long sheets of plastic material supported by wood or metal frames were introduced from Japan and first tried in an experimental station in the mid-1950's. By the mid-1960's the innovation had reached all sectors of the industry. Integration of new areas after the Arab-Israeli War in June 1967 altered market conditions in agriculture in Israel. Therefore, the period of study was not extended past 1967.

Ideally, to test and illustrate the innovation cycle model, one would utilize such data as skill (schooling) of farmers, size of farm operation, labor opportunity cost, and dates of adoption and exit. Such data are not available (though many are known to have adopted and then stopped using the innovation when profits declined). The data reported are areas planted to winter vegetables by sector in the Israeli agriculture for the period 1958/59 to 1966/67. These sectors are characterized by distinct socioeconomic traits,[6] and the illustration is mainly a comparative analysis of the sectorial diffusion process. Table 1 presents distributions

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[4] The crucial assumption in the present model in this respect is that experience diffuses freely (all firms have the same H). Imitation can be introduced into the model, for example, by making learning by nonadopters a function of the ratio of adopters to total number of producers.

[5] For details see [5].

[6] See [4, 14] for detailed descriptions and additional references.

Table 1. Sectorial distribution: schooling, selected product shares, and capital-labor ratios

	Capital-labor ratio in activity	*Kibbutzim*	*Moshavim*		Private	Arab Sector
			Established	Young		
1. *Median year of schooling* (males 14 years and over)		11.0	10.1	7.5	7.4	5.2
Capital-labor ratio (IL/day)[a]						
2. Overall[b,c]		11.9	6.6	5.9	4.7	3.3
Share in product (%)						
3. Total farm product		34.1	12.1	27.7	19.3	6.8
4. Vegetables	2.4	8.7	7.5	54.6	20.7	8.5
5. Winter grains	70.0	73.0	1.4	14.1	10.3	1.2
6. Citrus	4.5	19.0	13.7	22.4	44.1	0.8
7. Dairy	*kibbutz* 21.9 *moshav* 11.9	37.4	19.1	40.6	2.9	—
8. Covered vegetables 1961/62		17.2	22.9	27.5	32.4	—
9. Covered vegetables 1966/67		6.2	17.3	41.8	26.0	8.7

[a] Capital-labor ratios are ratios of capital outlays in IL (depreciation, machine rentals, maintenance, etc.) to number of labor days per unit of production; structures are included but land is not.

Data are from cost accounts, constructed and used for planning purposes. Where available (dairy, for example) different figures were used for the different sectors in calculating line 2.

[b] Data for lines 2–7 are for 1965.

[c] Line 2 pertains only to farming operations (the industrial sector in the *kibbutz* is not included).

Sources: Line 1: State of Israel, Central Bureau of Statistics, *The Settlements of Israel*, Part VI; Population and Housing Census 1961, Publication 28, Table 9.
Lines 2–7: Center for Agricultural and Settlement Planning, Ministry of Agriculture, Tel Aviv.
Lines 8–9: Vegetable production and Marketing Board, Tel Aviv.

of schooling, capital-labor ratio, lines of activities, and areas of vegetables under plastic covers. The following are a few additional descriptive remarks.

A *kibbutz* (plural: *kibbutzim*)[7] is a communal settlement of 200 to 2,000 inhabitants in which production and consumption are collective. The scale of operation is large, permitting members to specialize in a single line of production. Technology is advanced, and schooling and capital-labor ratio are the highest in the industry (Table 1).

The other cooperative sector is the *moshavim* (singular: *moshav*). In the *moshav*, farms operate their private family farms and cooperate in marketing and the purchasing of inputs and services. Schooling and capital intensity in the *moshav* are lower than in the *kibbutz* (Table 1), scale of operation is much smaller, most farms are diversified, and operators manage 3 to 4 lines of production (field crops, livestock, orchards, etc.). "Established" *moshavim* were founded in the 1920's and 1930's before the creation of the State of Israel (1948). The "young" *moshavim* were established after 1948. Most of their members immigrated to Israel in the 1950's with no prior agricultural experience.

The cooperatives, *kibbutzim* and *moshavim*, try to adhere to the principle of self-labor to avoid exploiting the work of others. Though this principle is not followed equally by all, it imposes a certain restriction for these settlements. *Private* (Jewish) agriculture, on the other hand, is based to a large extent on hired labor including seasonal employment. This is one of the reasons for lower capital-labor ratio in this sector than in the *moshav*.

The *Arab* is the only traditional farm sector in Israel. Levels of schooling and capital-labor ratio are the lowest in the industry (extended families contribute low opportunity-cost labor). This sector had in the past concentrated on dry farming, and irrigation (necessary for intensive vegetable production) is still not as widespread as in most of the Jewish farms.

Though markets, particularly for land and capital, are not perfect, data in Table 1 are consistent with basic assumptions of the model. Capital-labor ratios are positively correlated with schooling, and distribution of farm activities differs from sector to sector in agreement with sectorial comparative advantages, strengthening in this way the conjecture of a rising labor-opportunity-cost with schooling. Innovativeness is also in strong agreement with the model's assumption. The *kibbutzim* are by far the most innovative [7]. Young *moshavim*, being less experienced and schooled, are less innovative than the established ones. The private sector has a more diversified record in this respect, with some farmers very progressive and others far behind. The traditional Arab sector is generally the last to follow.

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[7] The sector of *moshav shitufi* with collective production and private consumption was included with the *kibbutz*.

Early stages of adoption of plastic covers were also in line with these general patterns. The innovation was first picked up by several entrepreneurial private farmers who were close to the university and the experimental station and by a few *kibbutzim*. Early stages were characterized by experimentation, learning (the right kind of plastic material, optimal timing of treatments, appropriate soils, etc.), and by more than a few disappointments. Perhaps typical of the kind of activities that form the industry's learning process at the different skill levels are: a *kibbutz* that operated a factory for plastic products developed and tested sheeting for covers and a tractor-mounted implement to construct the protective tunnels mechanically; and a great majority of hired laborers in the private sector were Arab villagers who on their jobs had the opportunity to learn by doing, and thus could bring the innovation back to their own farms.

If sectors were homogeneous with no intrasectorial differences in skills and other initial endowments, then, by the model all farms in a sector will adapt simultaneously at the same time. But the sectors, though markedly distinct, are not homogeneous—some *kibbutzim* have comparatively low labor opportunity costs, for example. Also, with experience, producers specialized and increased the volume of production—a possibility abstracted from the model. Therefore, in terms of the data, the innovation cycle is manifested as shifts in relative sectorial shares of production.

By 1961/62, *moshavim*, established and young, planted half the covered winter vegetables (Table 1, line 8). By 1966/67 the share of the *kibbutzim* had declined substantially, and the shares of the young *moshavim* and the Arab sectors had increased to a level larger than the shares of these sectors in total farm product. (The corresponding shares for the last two sectors for 1970/71 were 46.3 and 25.6 percent, respectively.) Similar findings are reported in Table 2 which gives estimates of the logistic function parameters (graphical examination confirmed the logistic time pattern of the diffusion process [5]). The intercept [the parameter $k/(1+b)$] is zero for the Arab sector and low for the young *moshavim*. The table also reveals a higher rate of adoption (the parameter a) for the latecomers—the Arabs, the private growers, and the young *moshavim*—a faster rearrangement in positions of static comparative advantages than rates of early (experimental) adoptions. One explanation for this (suggested by Welch) is that the variance of skills distribution is lower in these sectors, causing a speed-up of the diffusion in the lower skilled groups [consistent with the form of $n(w)$ in Figure 2].

Table 2. Estimated values of the sigmoidal function

$$y_t = \frac{k}{1+be^{-at}}^{a}$$

	k	b	a	$\frac{k}{1+b}$	$^*R^2$
Kibbutzim	571	15	.588	35.8	.983
Moshavim: Young	3,633	233	1.257	15.5	.990
Moshavim: Total	6,233	99	.979	62.3	.994
Private	1,935	132	1.585	14.6	.978
Arab sector	852	464,580	3.850	0	.974
Tomatoes	5,196	202	.998	25.7	.993
Cucumbers	3,257	64	1.153	49.8	.988
Peppers	1,837	3,654	2.077	.5	.979

[a] Data are annual observation [area planted, in dunam (=0.1 hectare)] 1961/62–1966/67, except for cucumbers and peppers for which data were available starting with 1958/59 season. y_t area in year t; k, a, b parameters; and $^*R^2$ correlation coefficient between the calculated and observed y values. Estimated by the method suggested by Tintner [11, pp. 208–211].

The equation for the established *moshavim* did not have a real value solution; the estimates for the pooled data of the total area in the *moshav* sector are reported.

The diffusion process is completed when the market is in long-run equilibrium. In addition to estimates of the sigmoidal equation reported in Table 2, the same function was estimated from the same data set imposing projected equilibrium k values, explicitly recognizing in this way the equilibrating properties of the process.

The basic approach was simple. It was assumed that long-run supply curves of winter vegetables were horizontal. Costs of production were accordingly estimated for each crop from technical data employing market wage rates.[8] Demand functions were estimated for the marketing season of plastic-covered crops. Equilibrium quantities were then calculated for each crop. Limited amounts of winter vege-

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[8] We assume that the 1968 data used already incorporated $g(w, \infty)$ and that production would be concentrated in the hands of producers whose w equals the market labor wage rate.

Table 3. Equilibrium estimates of the diffusion equation[a]

	Tomatoes	Cucumbers	Peppers
Projected Equilibrium Values:			
Total product (tons)	16,652	5,368	3,122
Area (dunams)	3,965	3,158	1,388
Regressions:			
No. of observations	5	8	7
a	.878	.913	1.131
	(7.752)[b]	(8.299)	(26.782)
b	79.2	207.5	455.0
	(12.275)	(9.620)	(44.603)
$^*R^2$ [c]	.960	.912	.949

[a] Data are the same as in Table 2. The equation

$$y = \frac{k}{1 + be^{-at}}$$

was estimated in the form $\log (k/y-1) = \log b - at + u_t$.

[b] Values in parenthesis are t values.

[c] $^*R^2$ is the correlation coefficient between the calculated and observed y values.

tables were obtained from unprotected fields in the warm inner valleys of the country, and these quantities were deducted from the equilibrium supply of plastic-covered vegetables. Dividing by average yield, equilibrium areas were projected. These areas are reported in Table 3 together with the estimated parameters.

The projected market equilibrium areas (Table 3) were lower than those obtained from the estimates (the parameter k in Table 2). This should be expected when individual growers do not perceive the market mechanism and underestimate the coming reduction in income. Rates of expansion are also consistently lower in Table 3. Unfortunately, this study could not be extended to allow detailed analysis of industry's approach to equilibrium. The early stages observed suggest a process of convergence, perhaps of the cobweb type, together with a shift of the distribution of the growers.

Conclusion

The example in the previous section illustrates that despite its simplifying assumptions, the model is capable of illuminating the economics of the adoption process. The process proceeded, according to comparative advantage positions, from skilled-intensive to labor-intensive producers. Several other innovation diffusion cases in Israel proceeded in a similar pattern (sheep raising, cut flowers, sugar beets). Needless to say, in many other diffusion cases alternative specifications will be more appropriate than the ones adopted here. For example, the effect of knowledge on productivity need not be Hicks-neutral; knowledge may be more important with one input than with others, and this aspect can be crucial in explaining diffusion of capital-intensive innovations. Or, in an industry with a small number of big firms that try to maintain secrecy, adoption of a new idea by a firm will depend more on the firm's own investment in R&D than on the industry's experience. The innovation cycle resembles in many aspects the product cycle in international trade, but for a model to give full account of the product cycle it should contain elements of import, export, national income levels, and similar relevant variables. It seems, however, that the present model can serve, with appropriate modifications, as the basic structure for other variants of the theory.

References

[1] Arrow, Kenneth J., "The Economic Implications of Learning by Doing," *Rev. Econ. Stud.* 29:155–173, June 1962.

[2] Griliches, Zvi, "Hybrid Corn: An Exploration in the Economics of Technological Change," *Econometrica* 25:501–522, Oct. 1957.

[3] Hufbauer, G. C., *Synthetic Materials and the Theory of International Trade*, London, Gerald Duckworth, 1966.

[4] Kanovsky, Eliahu, *The Economy of the Israel Kibbutz*, Cambridge, Harvard University Press, 1966.

[5] Kislev, Yoav, and Nira Shchori-Bachrach, "The Diffusion of An Innovation in the Israeli Agriculture," Economic Growth Center Discussion Paper No. 119, Yale University, July 1971, mimeo.

[6] Mansfield, Edwin, "Technical Change and the Rate of Imitation," *Econometrica* 29:741–763, Oct. 1961.

[7] Molcho, Sara, and Elihu Katz, "Personal and Other Factors in the Adoption of Agricultural Innovations in the Kibbutz and the Old-Established Moshav," in *Agricultural Extension, A Sociological Appraisal*, eds., Sara Molcho and Marcia Gitlin, Jerusalem, Keter Publishing House, 1970.

[8] Nelson, Richard R., "A 'Diffusion' Model of International Productivity Differences in Manufacturing Industry," *Am. Econ. Rev.* 58:1219–1248, Dec. 1968.

[9] ———, Merton J. Peck, and Edward D. Kalachek, *Technology, Economic Growth and Public Policy*, Wash-

ington, The Brookings Institution, 1967.

[10] NELSON, RICHARD R., AND E. S. PHELPS, "Investment in Humans, Technological Diffusion, and Economic Growth," *Am. Econ. Rev.* 56:69–75, May 1966.

[11] TINTNER, G., *Econometrics*, New York, John Wiley & Sons, Inc., 1952.

[12] VERNON, R., "International Investment and International Trade in Product Cycles," *Quart. J. Econ.* 80: 190–207, May 1966.

[13] WELCH, FINIS, "Education in Production," *J. Polit. Econ.* 78:35–59, Jan.–Feb. 1970.

[14] WINTRAUB, D., M. LISSAK, AND Y. AZMON, *Moshava, Kibbutz, and Moshav*, Ithaca, Cornell University Press, 1971.

Short Articles and Notes

Combining Income and Wealth: An Analysis of Farm Family "Well-Being"*

THOMAS A. CARLIN AND EDWARD I. REINSEL

Personal distribution of well-being of farm families relative to all U. S. families is substantially improved when wealth is considered along with money income. The "live poor and die rich" paradox facing older farm families could often be overcome by providing an easier means whereby they could use up equity in family living.

ECONOMISTS and policymakers have long been aware of persistent low money incomes in the farm sector. As late as 1970, 36 percent of the 2.4 million farm families[1] in the United States had money incomes of less than $5,000, twice the percentage for nonfarm families [8]. Part of the problem, many economists argue, is that farm families maintain and expand the farm production unit by saving a greater proportion of income than nonfarm families. This theme is echoed in the paradox, "farmers live poor and die rich."

Why should we be concerned with wealth? Because economic well-being is affected by wealth. Two individuals with low money incomes, one with substantial wealth, the other having little, would be economically dissimilar. Yet, in most income statistics, the two would be lumped together.

Farm families often hold large quantities of wealth. The average net worth of farm families in the United States in 1962 was about twice that of all U. S. families and unrelated individuals.[2] In addition, the relationship of net worth to income is different for farm families than for all families. Although the level of net worth increases with income, the ratio of net worth to income decreases for farm families as incomes increase from $2,500 to $15,000 (Table 1). Weisbrod and Hansen [11, p. 1321] reported an increase in the ratio for similar income levels for all consumer units.

How would wealth considerations affect the farm poverty picture? Older farm families accentuate the high net worth-income ratio for those with incomes of less than $2,500 (Table 2). Sixty percent of farm families headed by a person 65 or older had incomes of less than $2,500, and they account for 31 percent of all farm families with such low incomes. If a mechanism could be developed to convert wealth into an annual cash flow, older farm families might consume their assets and improve their level of living.

The problem of tying income and wealth together is not new in economics. Because income is a flow concept while wealth is a stock, addition is not appropriate. Weisbrod and Hansen [11] suggested converting wealth into a flow and adding it to income to obtain an improved measure of well-being. In the following, well-being will include both income and wealth consideration. Using the Weisbrod-Hansen model, current net worth (the measure of wealth used in this study) is converted into an annuity to yield a lifetime flow. The annuity is then added to current income. Weisbrod and Hansen summarized their model as follows:

$$Y_t^* = Y_t + NW_t \cdot A_n$$

where Y_t^* is the measure of well-being in time period t, Y_t is current income, NW_t is current net worth, A_n[3] is the factor which converts $1.00 to an n year annuity at a given rate of interest r, and n is the life expectancy of the family beyond time period t.

In this article the Weisbrod-Hansen model is applied to the farm sector to determine the effect of wealth on the distribution of Y^*. The

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* Appreciation is expressed to Walter Pike and Mary Darhanian for their help in developing the data. Views expressed are the authors' and do not necessarily represent those of the U. S. Department of Agriculture.

[1] Excludes 0.4 million unrelated individuals living on farms.

[2] The average net worth of all U. S. families and unrelated individuals in 1962 was $20,980 [4]. For comparison, an index of proprietors' equities in agriculture [6] was developed to deflate the average net worth of all U. S. farm families based on information from the 1966 Pesticide and General Farm Survey to 1962 levels. The resulting net worth for all U. S. farm families was $40,110.

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[3] $A_n = \dfrac{r}{1-(1+r)^{-n}}$.

Table 1. **Average income, average net worth, and net worth-income ratio for farm families by income, 1966[a]**

Income	Number of families	Average total income	Average net worth	Ratio of net worth to income
	Thousands	Dollars		
Less than $2,500	1,001	1,030	29,990	29.14
$2,500 to $4,999	806	3,650	39,010	10.70
$5,000 to $9,999	962	6,920	47,460	6.87
$10,000 to $14,999	263	11,820	63,790	5.40
$15,000 to $24,999	84	18,140	136,910	7.55
$25,000 or more	33	43,290	346,340	8.00
All families	3,149	5,300	46,630	8.80

[a] Based on tabulations from the 1966 Pesticide and General Farm Survey.

latest readily available data containing complete income and wealth information was the 1966 Pesticide and General Farm Survey. Although newer data would have been preferred, the authors feel the results are still valid.

Assumptions

Several assumptions were made about the farm sector in addition to those of the above model.

The model requires knowledge about the existence of the family beyond time period t. Each observation was assumed to represent a family with both husband and wife present. The remaining life of the family, the value for n in the model, was based on the life expectancy of the wife who was assumed to be two years younger than her spouse [10].

Income reported in the pesticides survey reflects returns from all resources including equity capital. To avoid double counting, returns to equity capital were estimated and excluded from current income before applying the model. A precise calculation of the contribution of capital to current income, particularly for the farm, was virtually impossible. To estimate such returns, a flat amount of $15,000 was deducted from net worth to cover unproductive and unmeasured resources on the farm (e.g., house, etc.). A 4 percent return to capital was assumed and applied to "productive" net worth.

An annuity interest rate of 6 percent was used. The results are sensitive to both the interest rate used in calculating the annuity and the rate of return to equity capital. Several combinations of the two are being analyzed in the overall study.

After the data were edited for missing information, 5,649 observations were retained for analysis. A weighting scheme was devised which expanded the sample to 1964 Census of Agriculture estimates of farm numbers. All farms were assumed to be operated as a sole proprietorship family farm; thus, each observation represented a family. Sole proprietors accounted for 96 percent of the farm tax returns filed in 1966 [9]. Although some of the observations may not represent families, it was assumed that such observations would not greatly alter the results.

Definition of Terms

The analysis is concerned with the well-being of farm families. Thus, income as used in this study includes that from both farm and non-

Table 2. **Average income, average net worth, and net worth-income ratio for farm families by age, 1966[a]**

Age of family head	Number of families	Average total income	Average net worth	Ratio of net worth to income
	Thousands	Dollars		
Less than 35 years	335	5,960	31,500	5.28
35 to 54 years	1,493	6,300	48,280	7.67
55 to 64 years	807	4,510	46,930	10.40
65 years and over	514	3,210	51,250	15.98
All families	3,149	5,300	46,630	8.80

[a] Based on tabulations from the 1966 Pesticide and General Farm Survey.

farm sources. Nonfarm income includes wages and salaries, rental income, interest, dividends, retirement pensions, social security, and other transfer payments. Farm families receive much of their total income from nonfarm sources. Farming was the major source of income for only 1.2 million persons among 3 million reporting some farm earnings for tax purposes in 1966 [5, p. 6]. In a similar manner, both farm and nonfarm assets and liabilities were used in deriving net worth.

Results

Distribution of well-being among farm families, Y^*, became more equal with the incorporation of wealth for the United States and for each farm production region used by the Economic Research Service (Table 3 and Fig. 1). The Y^* distribution lies to the right of the Y_t distribution (Fig. 2). In 1966, 58 percent of U. S. farm families had money incomes of less than $5,000. When wealth was included in the measure of well-being, the proportion with less than $5,000 was reduced to 39 percent. The same general result was apparent for each region when the Gini ratios were compared. The Mountain and Pacific regions were least affected by incorporating wealth because of the large number of sample farm families incurring losses in 1966.

The dynamic aspects of including wealth in Y^* are covered up in Table 3. Families with incomes of under $2,500 accounted for 32 percent of all farm families whose incomes were analyzed. When wealth was considered along with income, 45 percent of the under $2,500 group moved to the $2,500–$4,999 class (Table 4). In addition, about 8 percent moved to the $5,000–

Table 3. Distribution of income and well-being of farm families for the United States and by region, 1966[a]

Item	Number families	Families with—						Mean	Median	Gini ratio
		Less than $2,500	$2,500–$4,999	$5,000–$9,999	$10,000–$14,999	$15,000–$24,999	$25,000 or more			
	Thousands	*Percent*						*Dollars*		
					United States					
Income	3,149	32	26	30	8	3	1	5,300	4,200	.475
Well-being	3,149	15	24	39	14	6	2	7,600	6,100	.414
					Northeast					
Income	227	26	17	38	15	2	2	6,700	5,900	.436
Well-being	227	6	22	41	21	7	3	8,800	7,800	.349
					Appalachian					
Income	529	44	25	24	5	1	1	4,100	3,000	.469
Well-being	529	24	31	32	9	3	1	5,700	4,500	.414
					Southeast					
Income	273	54	19	21	4	2	b	3,600	2,300	.553
Well-being	273	37	25	24	9	4	1	5,300	3,700	.499
					Delta					
Income	252	45	22	25	5	2	1	4,500	3,100	.524
Well-being	252	27	28	28	11	4	2	6,300	4,400	.470
					Corn Belt					
Income	661	21	29	36	10	3	1	5,900	5,000	.395
Well-being	661	6	22	47	17	6	2	8,300	7,100	.331
					Lake States					
Income	343	29	32	31	7	1	b	4,700	4,000	.398
Well-being	343	11	29	45	10	4	1	6,600	5,700	.320
					Northern Plains					
Income	271	27	32	33	6	2	b	5,000	4,200	.410
Well-being	271	10	25	42	16	6	1	7,700	6,500	.349
					Southern Plains					
Income	293	26	23	31	11	7	2	6,900	5,200	.467
Well-being	293	7	19	40	18	11	5	10,000	7,700	.406
					Mountain					
Income	134	49		35	11	3	2	6,500	5,000	.595
Well-being	134	30		37	20	10	3	11,500	6,300	.586
					Pacific					
Income	166	41		36	15	6	2	6,800	6,100	.516
Well-being	166	18		48	20	10	4	9,800	8,300	.412

[a] Farm Production Regions: *Northeast*—Me., N. H., Vt., Mass., R. I., Conn., N. Y., N. J., Pa., Del., Md.; *Appalachian*—Va., W. Va., N. C., Ky., Tenn.; *Southeast*—S. C., Ga., Fla., Ala.; *Delta*—Miss., Ark., La.; *Corn Belt*—Ohio, Ind., Ill., Iowa, Mo.; *Lake States*—Mich., Wis., Minn.; *Northern Plains*—N. D., S. D., Nebr., Kans.; *Southern Plains*—Okla., Tex.; *Mountain*—Mont., Idaho, Wyo., Colo., N. M., Ariz., Utah, Nev.; *Pacific*—Wash., Oregon, Cal.

[b] Less than .5 percent.

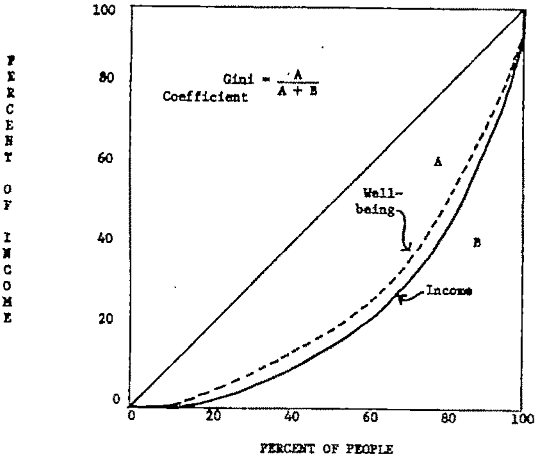

Figure 1. Lorenz curve for income and well-being, United States farm families, 1966

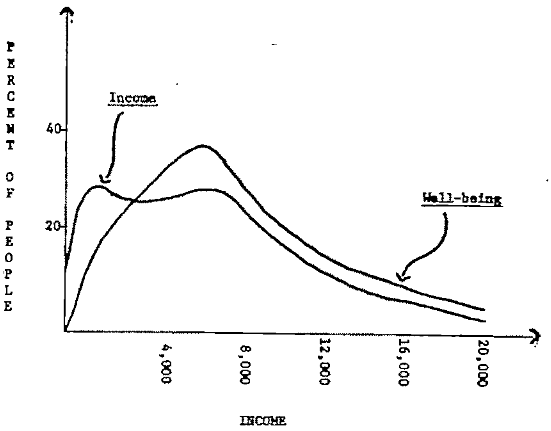

Figure 2. Distribution of income and well-being, United States farm families, 1966

$9,999 class and 2 percent moved into classes with $10,000 or more. Thus, only 45 percent of families with less than $2,500 before including wealth remained at that level afterwards. Of those beginning with $2,500–$4,999, 57 percent moved up one class as a result of considering wealth and 39 percent remained in the class. Therefore, 59 percent of families in the $2,500–$4,999 class when wealth was included were originally in the less than $2,500 class. Many low-income farm families would seem to be substantially better off if wealth could be considered.

The results of this study appear to run contrary to those of Weisbrod and Hansen for all families in the United States. They concluded that the distribution of well-being became less equal with addition of net worth [11, pp. 1320–21]. This difference is due to the net worth-income ratio decreasing as income increased for farm families because older farm operators often have low current incomes but relatively large net worths.

Historically, farm families have had lower money incomes and their incomes have been less equally distributed than those of nonfarm families [1]. Although the degree of overlap between the farm and nonfarm distribution of money incomes, as measured by the index of integration, increased from 0.64 in 1960 to 0.75 in 1966, there still was a sizable "income gap." However, when wealth was considered along with money income, differences in well-being between the two sectors were not as great as direct money income comparisons might suggest (Fig. 3 and Table 5) [7, 11]. Although comparison of cross-sectional findings from different years may appear questionable, there is some evidence that distribution of net worth for the population as a whole has remained fairly stable, at least between 1953 and 1962 [2].

Table 4. Transition matrix for farm families as a result of incorporating wealth into the distribution of Y^*

Income size classes	Starting State	Well-being size classes: Less than $2,500	$2,500–$4,999	$5,000–$9,999	$10,000–$14,999	$15,000–$24,999	$25,000 or more
	Thousands	*Thousands*					
Less than $2,500	1,001	460	448	75	12	6	
$2,500–$4,999	806		314	463	25	2	2
$5,000–$9,999	962			685	246	26	5
$10,000–$14,999	263				172	89	3
$15,000–$24,999	84					63	21
$25,000 or more	33						33
Total	3,149	460	762	1,223	454	186	64

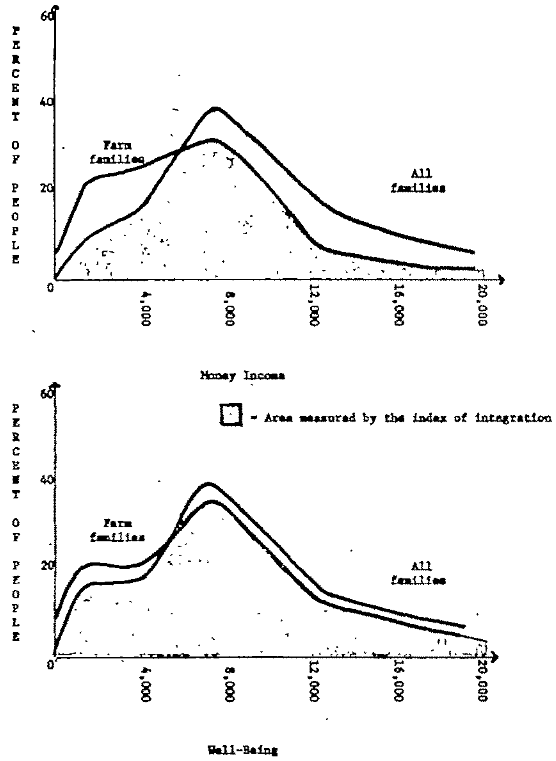

Figure 3. Distribution of money income and well-being of all families and farm families for the United States

Providing a Means for Asset Consumption for Older Farm Real Estate Owners

Several alternatives are available to older farm families for liquidating their farm real estate assets for use as retirement income. Lee and Brake [3], for example, suggest ways in which older farm families could alter their portfolios to increase current income. Some of the Lee-Brake proposals would require management of nonfarm securities, others would not. However, many older low-income farm people own real estate which they cannot sell without losing their home and a major source of income.[4] Aside from psychological effects, the cost of replacing home property plus transfer costs could often use up much of the net from a sale.

A completely voluntary program could be established which would allow older farm people to consume their equity over time while still retaining the other benefits of property.[5] As envisioned, the program would in no way substitute for or affect social security payments. The program could provide a valuable income supplement, reduce welfare costs, and leave older people with the feeling that they were paying their own way.

Table 5. Comparison of the distribution of well-being for all families in 1962 reported by Weisbrod and Hansen and that of farm families in 1966, 4 percent annuity

Income size classes	All families[a]	Farm families[b]
	Percent	
Less than $3,000	18	23
$3,000 to $4,999	17	21
$5,000 to $9,999	42	38
$10,000 to $14,999	15	13
$15,000 to $24,999	6	4
$25,000 and over	2	1
Gini ratio	0.42	0.41
Index of integration	0.91	

[a] Weisbrod and Hansen [11].
[b] Pesticides Survey.

The individual or couple would agree to allow an agency[6] to record a lien against the equity in their property in exchange for entitlement to future payments. The agency could provide a monthly payment for life and allow older low-income people to retain a life estate in their property. Current income from producing crops and livestock or renting land and buildings could continue to go to those benefiting from the program. Payment would continue until the participants were deceased; at death the property would be sold with the agency having first rights. Any residual value not already paid to participants or used to pay interest would go to heirs. No statement of need would be required.

The amount of the monthly payment would be influenced by the expected life of the individual or couple, value of equity in real estate holdings, and the interest rate charged by the agency. Lower interest rates would substantially increase monthly payments. For example, the basic monthly payment is increased from $3.44 per $1,000 of real estate value at a 6 percent interest rate to $4.41 per $1,000 of real estate value at 3 percent, assuming a 15-year life expectancy.

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[4] Unpublished data available from Allen G. Smith, Farm Production Economics Division, ERS, USDA, indicate that equity in farm real estate constituted 56 to 78 percent of total net worth of farm operators 65 and over in 1966.

[5] Many older nonfarm families own valuable residential property yet have low money incomes. Although the following program is geared to farm families, the concept could also apply to older nonfarm familes.

[6] The agency would most likely be government-sponsored because there is little incentive for a private lending institution to engage in such a program.

Real estate taxes and property insurance could be paid as a deduction from the basic monthly payment. This would assure that these ownership costs were paid and would follow the practice of many lenders who pay such expenses in the name of their mortgagees. No capital improvement would be made by the agency. Property improvements made by participants could increase the value of the residual going to heirs. Sale of real property or mineral rights or any other action affecting property value would be prohibited without permission from the agency.

Basic advantages of such a program, in addition to those cited above, include avoiding capital gains tax, brokerage fees, and other selling costs associated with asset liquidation. The program could also allow older people to benefit from future appreciation of real estate, a unique feature not usually available in options such as the conventional land sales contract. The program could allow for periodic revaluing of property (possibly every three to five years). If the property value increased substantially, the monthly payment could be recomputed based on remaining net value of the real estate and the person or couple's expected life at that time.

A question arises on how to continue payments to those who live longer than expected, thus receiving more than the value of their property. One possibility would be to subsidize those living well beyond their expected years. In essence, the family would consume its assets before receiving "welfare" benefits. Another possibility would be to reduce actual payments below computed payments by a given percentage. For example, a couple with a basic annuity of $86 per month might receive $77.40. This 10 percent reduction would help assure that some property value would remain at the end of the expected life of the payee. It would also minimize overpayment in the event that property value declined. A third possibility would be for the agency to retain part of any residual remaining at the end of the life of those dying earlier than expected. Such a provision would benefit older people but would reduce residuals going to heirs.

The program would affect only individuals with real estate assets. But low-income farm people often have large assets. The program would not lessen the well-being of those without real assets or the general public, unless the program was subsidized from general tax funds. Allowing consumption of assets before actually subsidizing those living beyond their expected life may be more equitable from society's viewpoint. Heirs of those benefiting from the program would inherit less, but many would probably prefer that older relatives use their assets in current living. The program would benefit potential heirs by reducing the need for remittances to relatives with inadequate incomes.

Summary

Wealth is important when discussing the economic well-being of farm families. The average net worth of farm families is nearly twice that for all families in the U. S. When both income and net worth were included in a measure of well-being for farm families, the average level increased and the distribution appeared to be more equal than with simple income comparisons. Also, the disparity in well-being between the farm and nonfarm sectors was less pronounced.

The Weisbrod-Hansen study of all U. S. families shows the distribution of well-being to be less equally distributed when wealth is included. In this study, net worth-income ratios decreased as farm family income increased. Thus, the distribution of well-being was less concentrated for farm families when wealth was considered. Also, older farm operators generally have low current incomes but some have relatively large net worths. It may be especially important to consider the wealth position of older people in measuring their well-being. The tendency to "live poor and die rich" could be lessened by making it more convenient for older farm families to transfer wealth into cash flow.

References

[1] CARLIN, THOMAS A., "Farm Families Narrowed the Income Gap During the 1960's," *Agr. Fin. Rev.* 33:22–26, June 1972.

[2] LANSING, JOHN B., AND JOHN SONQUIST, "A Cohort Analysis of Changes in the Distribution of Wealth," *Six Papers on the Size Distribution of Wealth and Income*, Studies in Income and Wealth, No. 33, New York, National Bureau of Economic Research, 1969.

[3] LEE, W. F., AND J. R. BRAKE, *Conversion of Farm Assets for Retirement Purposes*, East Lansing, Michigan State University, Agricultural Experiment Station, Research Report 129, Jan. 1971.

[4] PROJECTOR, DOROTHY S., AND GERTRUDE S. WEISS, *Survey of Financial Characteristics of Consumers*, Washington, Board of Governors of the Federal Reserve System, Aug. 1966.

[5] REINSEL, EDWARD I., *People with Farm Earnings—Sources and Distribution of Income*, Washington, USDA, ERS-498, March 1972.

[6] U. S. Department of Agriculture, Economic Research Service, *Agricultural Finance Review*, Vol. 32, Supplement, Jan. 1972.

[7] U. S. Department of Commerce, Bureau of the Census, *Income in 1966 of Families and Persons in the United States*, Series P-60, No. 53, Dec. 28, 1967.

[8] ———, *Income in 1970 of Families and Persons in the United States*, Series P-60, No. 80, Oct. 4, 1971.

[9] U. S. Department of the Treasury, Internal Revenue Service, *Statistics on Income 1966, Business Income Tax Returns*, Publication 438, June 1969.

[10] U. S. Public Health Service, *Vital Statistics of the United States—Life Tables*, Vol. II, Section 5, Washington, U. S. Department of Health, Education and Welfare, 1968.

[11] WEISBROD, BURTON A., AND W. LEE HANSEN, "An Income-Net Worth Approach to Measuring Economic Welfare," *Am. Econ. Rev.* 58:1315–1329, Dec. 1968.

Optimal School District Size Emphasizing Rural Areas*

FRED WHITE AND LUTHER TWEETEN

Cost of providing elementary and secondary education is estimated for rural areas of Oklahoma. Unit cost curves are derived for instruction, administration, plant operation and maintenance, buildings, equipment, and transportation. Optimal school district size, derived by combining these unit cost curves, varied by educational program and student density.

ADEQUATE schooling is vital to the well-being of rural youth whether as adults they remain in the community or migrate. In rural areas the high dependency rates, low incomes, and reliance on local financial support for common schools coupled with the need to improve schooling quality create pressures to raise schooling efficiency. Larger school districts offer substantial economies through bigger classes and spreading overhead costs of specialized equipment, administration, and other items over more students. But larger school districts also entail diseconomies particularly from increasing transportation costs per student. Trade-offs between internal schooling economies and transportation diseconomies determine the shape of the long-run average cost curve and hence determine the optimal school district size.

Previous research on school district size has focused on per-unit costs associated with school districts of different sizes. Wright and Pine [11] analyzed factors affecting per-pupil costs for rural high school districts in central Kansas. Measures of schooling quality were not included even though they were considered important. School district size accounted for most of the variation in per-pupil operating costs. Significant cost reductions could have been achieved by enlarging the district size.

Although several other researchers including Hirsch [4], Schmandt and Stephens [9], Miner [6], and Hanson [3] have examined economies of size in public education, their work has not been directly applicable to rural areas. These studies have emphasized heavily populated urban areas. For example, Hanson reported that in general, economies of size accrued to about 50,000 pupils in average daily attendance [3, p. 91]. Such results are obviously misleading for rural areas. However, these studies did provide useful methodology for subsequent analyses. For example, Schmandt and Stephens [9] thought expenditures were closely related to schooling quality, as measured by educational activities. They reported that school district operations exhibited economies of size in providing a given quality of education, but larger per capita expenditures were usually associated with larger populations.

Additional studies on economies of size in education have refined measures of schooling quality. Riew [8] utilized data on individual public high schools in Wisconsin. Variations in educational programs and qualities among schools were reduced by considering only accredited schools with typical teacher salaries. An increase in enrollment with other variables held constant decreased average per-pupil operating expenditures until enrollment reached 1,675 pupils in average daily attendance (*ADA*). Cohn [1] evaluated the per-pupil cost function for Iowa high school districts. Incremental test scores were used as a proxy for educational quality. Per-pupil costs indicated the existence of significant economies of size for Iowa high schools to 1,500 pupils in *ADA*. Using average achievement test scores as a quality variable, Osburn [7, p. 115] reported that most economies in Missouri high school districts were achieved with 1,500 pupils in *ADA*. These studies gave no consideration to student density which could affect optimal school district size.

Past studies have largely concentrated on estimating long-run average cost curves for education (instruction, administration, plant operation and maintenance, buildings, and equipment) similar to the hypothetical average cost curve for education shown in Figure 1. In many empirical cases, this curve exhibited both economies and diseconomies of size. However, diseconomies resulting from inefficient internal operations are not likely to be very important in elementary and secondary education in rural areas. Major diseconomies accrue from trans-

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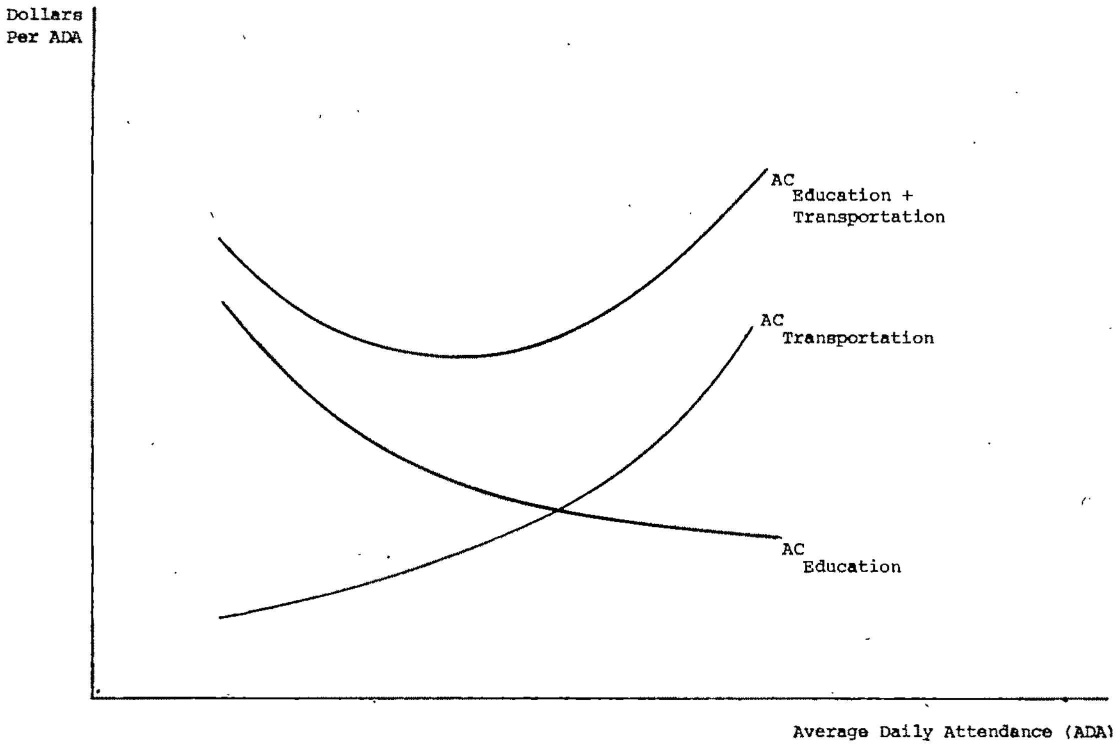

Figure 1. Average cost (AC) of education and transportation per ADA

portation costs which are particularly prominent in sparsely populated areas. Average cost of transportation for a given population density is also shown in Figure 1. These two curves can be combined to derive the average cost curve relevant for determining how large the school district should be. The optimal size of school district is defined as that which has minimum long-run average costs with resources combined in a least-cost manner.

By ignoring transportation costs, past studies have provided misleading guidelines for optimal school district size, especially for rural areas. This study, which shows long-run average costs for a given quality of elementary and secondary schooling for various student densities, provides methodology and empirical estimates to guide school district consolidation. Quality measures used in this study are average eleventh grade composite achievement scores and the number and type of credit units offered. The data are for Oklahoma, but the structure of schooling is similar in other states. Thus, with some modifications the results could be applied more generally.

Data

Data used in this study were collected by Oklahoma's State Department of Education. The state-wide survey measured school programs, student backgrounds, and student attainment. In a stratified sample, the population of school districts in Oklahoma was divided into subpopulations according to geographic location and size of school district. The sample was designed to be proportional, sampling 5 percent of the districts in each stratum, and was drawn independently and randomly in each stratum. The survey conducted in March 1970 involved 1,903 eleventh graders. Complete data were acquired from 27 independent Oklahoma school districts. Since there were several school sites in many districts, the number of school sites was well above 27. Stratification insured that every geographic region in the state and district size class was represented in the sample.

After the schools were randomly drawn, students in the eleventh grade of the high schools completed standardized achievement tests. In addition, data were acquired from school administrators concerning finances, program, organization, facilities, equipment, teacher qualifications, and community characteristics. Although observations were made at the individual student level, the school district is the unit of analysis in this report. The following sections show how these data were combined to develop the various cost relationships which were required to determine optimal school district size.

Instruction

The major component of educational costs is instruction, those activities dealing directly with the teaching of students. Instructional expenses include the salaries of teachers, principals, and guidance personnel. These costs also include salaries of secretarial and clerical assistants and expenditures for textbooks, school libraries, audiovisual material, and teaching supplies.

Instructional costs vary because of differences in the quality of program offerings. To make a valid comparison of costs among schools of different sizes, the program quality must be held constant. For this analysis the high school course offerings were standardized according to number and type of vocational and nonvocational courses offered.

Three high school curriculums were considered in the analysis. The first program (typical for many small rural high schools) included 38 academic units—the "minimum" for accreditation. However, this program does not meet the needs of all students. The second program was designed to be "adequate" for even vocation-oriented students. This program, containing 30 academic units and 8 vocational units, was developed from courses offered by accredited districts which provided both academic and vocational courses. The third program, a more extensive or "desirable" program of 38 academic units and 8 vocational units, offered the same courses as the other two programs combined.

The number of high school teachers was calculated from the number of classes required to meet the specified program. The number of elementary and junior high teachers was based on *ADA* and a student-teacher ratio of 27–1, the state average. Cost calculations were based on the assumption that two courses can be combined in a single classroom under one teacher until the number of students in combined courses exceeds the maximum class size. Salaries were state averages: $7,137 for high school teachers and $6,834 for elementary and junior high teachers.

Costs of principals, guidance counselors, and secretaries were based on average salaries and adequate personnel-to-*ADA* ratios. The average full-time equivalent principal-to-*ADA* ratio was 3:1000. Adequate full-time equivalent guidance counselors and secretarial personnel-to-*ADA* ratios were 4:1000 and 3:1000, respectively. Average salaries for principals, guidance counselors, and secretaries were $9,028, $8,657, and $4,000, respectively. Average instructional cost curves for elementary and secondary education are shown in Figure 2.

Attendant Costs

Attendant costs can be broken down into a fixed component, embodied in plant and equipment, and a variable component termed overhead. Major overhead costs include administration and plant operation and maintenance. Administration consists of those activities which regulate and control the affairs of the school district. Plant operation and maintenance include all current expenditures for keeping the grounds, buildings, and equipment in good condition.

Overhead

Long-run average cost curves for overhead were estimated using data from the 27 sampled school districts in regression analysis. Overhead costs per pupil varied by class size, school district size, and quality of the educational program. Class size and school district size were represented by pupil-teacher ratio and average daily attendance (*ADA*), respectively. Examination of the data revealed overhead costs declined rapidly with initial increases in *ADA* and the pupil-teacher ratio. After achieving these substantial economies in size, administrative costs remained relatively constant over a large range of *ADA*, but plant operation and maintenance costs exhibited slight diseconomies when *ADA* was very large. Forms of the variables which best reflected these relationships were (1) pupil-teacher ratio and pupil-teacher ratio squared to represent cost economies accruing from increases in class size, (2) inverse of *ADA* to represent cost economies accruing from increases in school district size, and (3) *ADA* to represent diseconomies accruing from increases in school district size. Since differences in per pupil costs may reflect differences in program quality, the average achievement score was included in the cost function to represent a quality indicator variable.

The regression results are shown in equations (1) and (2). Standard errors are shown in parentheses below the regression coefficients. The computed t-values indicate that the regression

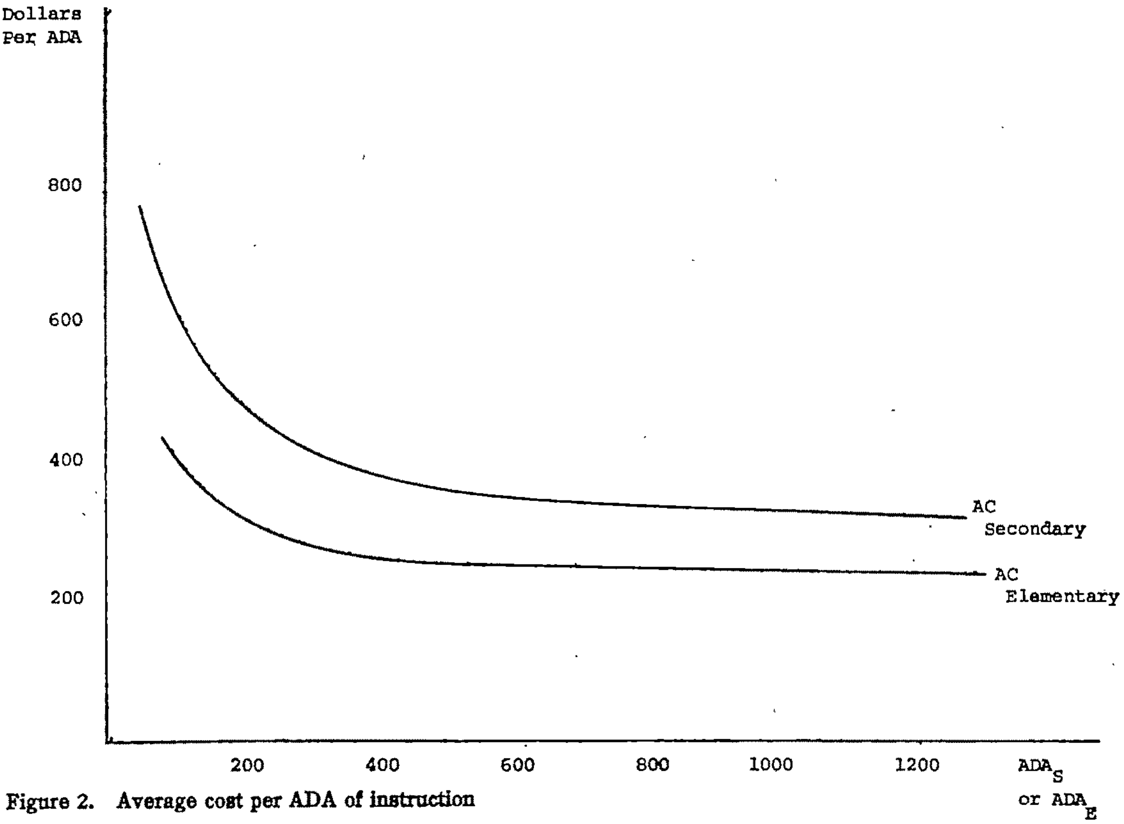

Figure 2. Average cost per ADA of instruction

coefficients are all significant at least at the .10 level.

$$(1)\quad AD = \underset{}{311.743} + \underset{(.312)}{.528}\,ACH - \underset{(4.730)}{26.391}\,PTR + \underset{(.097)}{.513}\,(PTR)^2 + \underset{(2.679)}{6.694}\,(1/ADA)$$

$$R^2 = .937$$

$$(2)\quad POM = 133.101 + \underset{(.380)}{1.612}\,ACH - \underset{(8.591)}{16.516}\,PTR + \underset{(.179)}{.298}\,(PTR)^2 + \underset{(.193)}{.338}\,ADA + \underset{(3.617)}{12.839}\,(1/ADA)$$

$$R^2 = .852$$

where:

AD is average cost per *ADA* of administration;
POM is average cost per *ADA* of plant operation and maintenance;
ACH is average eleventh-grade composite achievement score;
PTR is pupil-teacher ratio; and
ADA is average daily attendance in 1,000 units.

The long-run overhead-cost curve for a given level of achievement is derived by finding the minimum cost with respect to the pupil-teacher ratio for each level of *ADA*. Under actual conditions, a school district may operate on a short-run cost curve above the level that is achieved under a full, long-run adjustment. The short-run curves are based on a given size plant. These short-run curves show that average administrative costs per *ADA* can be high with too many teachers and that average plant operation and maintenance costs per *ADA* can be high with too many classrooms in operation.

Facilities

Educational facilities consist of school buildings and equipment. Construction costs for buildings include expenditures for general con-

Table 1. **Fixed and variable cost of operating school buses, by size of bus**

Seating Capacity	List Price	Depreciation Per Mile of Bus Route	Interest on Average Annual Investment	Cost of Fuel and Lubricants Per Mile of Bus Route	Cost of Maintenance Per Mile of Bus Route	Annual Cost of Insurance
30	$6,577	$36.43	$216.38	$16.64	$12.44	$218.95
36	6,695	37.20	220.94	18.76	12.73	226.52
42	7,172	39.85	236.68	20.07	13.97	237.11
48	7,328	40.72	241.82	21.18	14.12	244.84
54	7,719	42.89	254.73	22.09	14.93	254.65
60	8,491	47.18	280.20	23.00	16.81	267.88
66	8,851	49.18	292.08	23.70	17.48	277.42

struction, installation of fixtures, architectural services, paint, and cost of planning. Equipment costs consist of all expenditures for items of furniture, furnishings, and machinery that are not integral parts of the building.

Since this long-term analysis allows organization of school districts to change, building and equipment investment must also be allowed to change. Data on recently built schools give the general cost of construction by size of school district [2]. Equipment costs reported by Isard and Coughlin [5] were adjusted to 1969–70 price levels by the Bureau of Labor Statistics commercial furniture price index. Equations (3) and (4) derived from data presented in the above two sources give a representative picture of the size-cost relationship of facilities (excluding vocational equipment) in elementary and secondary education in school year 1969–70.[1]

$$(3)\quad FAC_E = 1667.464 - 56.842(ADA_E) + 26.893(1/ADA_E)$$

$$(4)\quad FAC_S = 2316.505 - 253.542(ADA_S) + 9.763(1/ADA_S)$$

where:

FAC is average cost per ADA of facilities;
ADA is average daily attendance in 1,000 units;
E is elementary school; and
S is secondary school.

Major economies of size in providing facilities accrued to 300 ADA in elementary schools and 600 ADA in secondary schools.

The average cost per ADA of facilities was based on the number of elementary students, secondary students, and secondary vocational students by courses [10, p. 93]. Facility costs were converted to annual costs of depreciation, insurance, and interest on investment. The facilities' operating life was assumed to be 25 years for nonvocational equipment, 10 years for vocational equipment, and 50 years for buildings. It was also assumed that school buildings would be salvaged at 20 percent of original cost, while equipment would have no salvage value at the end of its operating life. In all cases, a 6 percent interest rate was used.

Transportation

Public transportation is generally provided for students whose residence is not within walking distance of school. Insofar as possible, buses are approved to go at least within one-half mile of each pupil's home. Transportation costs in rural areas are particularly important since students are so dispersed and school districts are so large.

In most districts the most expensive transportation item was drivers' salaries. The sampled school districts' average salary per mile of bus route was $75.94 with a standard deviation of $38.13. There was no stable relationship between bus drivers' salaries and either total miles or total miles adjusted for the number of students. District salary schedules were typically based on a school district's wealth and local wage rates rather than a uniform state salary schedule. Therefore, the salary used in computing transportation costs was the sample average.

The least expensive combination of body and chassis was selected for each size of bus. List prices by size of bus are presented in Table 1. Depreciation costs were computed from these list prices and a seven-year operating life, the state average. The approximate cost per mile traveled was derived from the cost per mile of bus route using the number of days traveled (180) and the number of times per day the bus route was covered.

Cost of fuel, lubricants, and maintenance is a

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[1] Statistical properties of the equations are not presented because the values were averages for specific intervals, and consequently the equations gave nearly perfect fits.

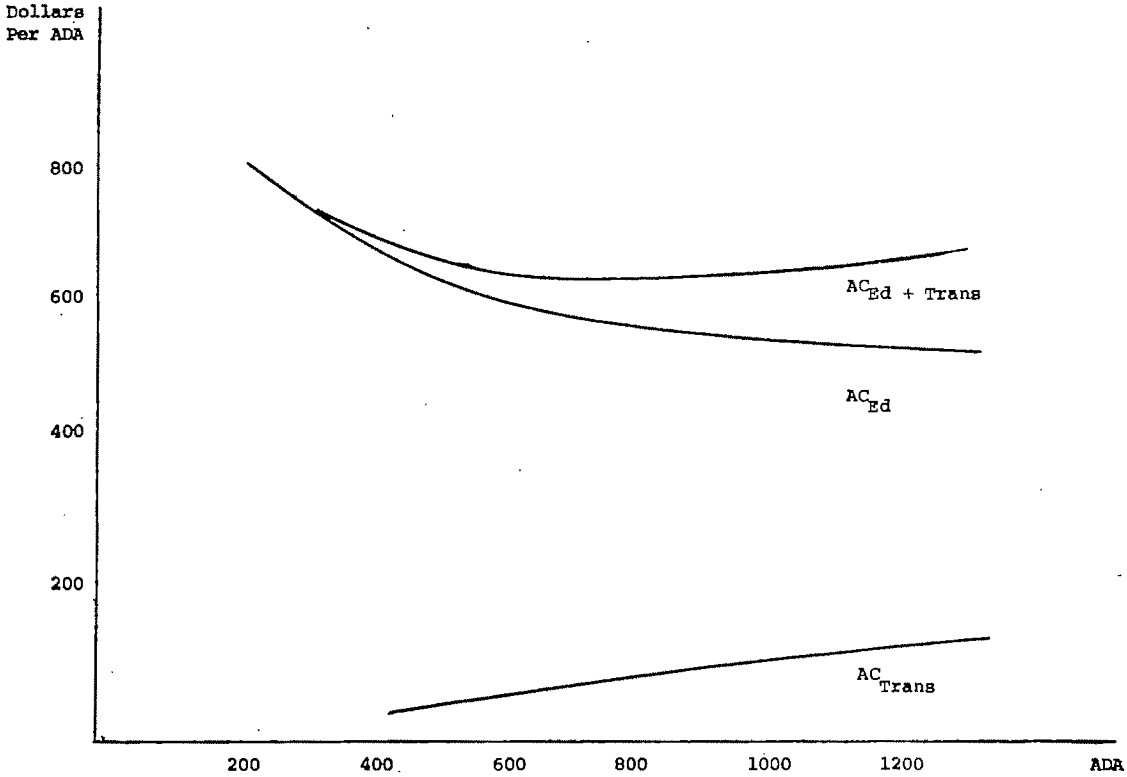

Figure 3. Average cost of education and transportation per ADA for a school district with a student density of 1.8 transported students per square mile

large component of transportation costs. School buses make many starts and stops and gas mileage is low. A 30-passenger bus in rural areas typically gets 6.5 miles per gallon. The cost of lubricants was assumed to be 15 percent of the fuel cost. Maintenance includes cost of material and labor for repairs, equipment replacement such as tires, as well as the cost of overhauls. The costs of operation and maintenance are also presented in Table 1.

Insurance and interest on investment are the last components of transportation costs. The charge for interest was based on the average annual investment and a 6 percent interest rate. The cost of insurance was based on a typical package of comprehensive, collision, and liability insurance. The liability coverage had 100, 300, and 25 in thousand dollars of individual bodily injury, total bodily injury, and property damage, respectively.

A simulation program was used to determine the size and number of buses used, as well as the distance traveled in transporting students from their homes to school. This program considered both the size of district and density of transported students. For a generalized discussion of student transportation costs, it was assumed that the students were evenly dispersed and were transported to a central location. This formulation is similar to the situation in many rural areas in which there is only one high school and one or more elementary or junior high schools centrally located.

Since time spent in busing involves an increasingly important disutility to students and parents, the program took into account the time that students were in transit. It appears feasible but unrealistic from a school administrator's point of view to assign a monetary cost to student's time lost in busing. Imposing a limit on the time that students can spend in transit appears to be a more useful method for reflecting this disutility of busing. This study assumes that no student can be in transit for more than one hour, a maximum limit in effect in several sparsely populated areas.

All costs of operating school buses in Table 1 were combined with the information on routing provided by the simulation program to derive the average cost of transporting students by

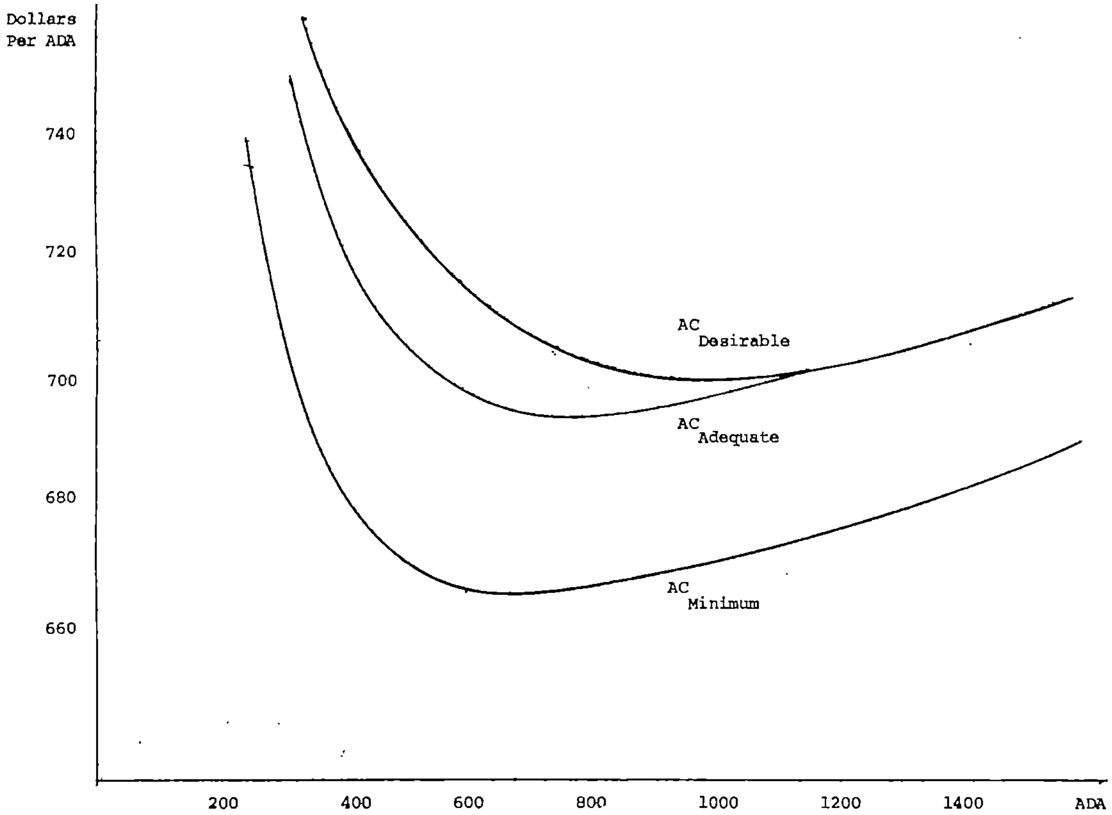

Figure 4. Average cost of education and transportation per ADA for a school district by high school curriculum

various student densities and district sizes [10]. Curves for the low-density areas show that it is economically infeasible to transport large numbers of students in these sparsely populated areas.

Optimal School District Size

Average cost curves derived above can be combined to determine the optimal school district size. Educational costs include the cost of instruction, administration, plant operation and maintenance, and annual costs of plant and equipment. The average educational cost curve, adjusted to a standard quality of program, exhibits significant economies of size to 800 *ADA* as shown in Figure 3.[3] The cost curve was standardized for a high school program offering 30 academic units and 8 vocational units and achievement equal to the sample average of 77. The average transportation cost curve for a student density of 1.8 transported students per square mile, typical for rural areas, is presented in Figure 3. This analysis assumes there were 265 nontransported students, the sample average. Cost economies in instruction and attendant functions accrue from larger numbers of students, but cost diseconomies from transportation arise as more students must be brought to school.

The average transportation and educational cost curves were added together to get the average cost of all the school district's functions (Fig. 3). This curve's minimum occurs at 675 *ADA*. However, the curve is very flat between 400 and 1,100 *ADA*. School districts can operate anywhere within this range without significant differences in per-unit costs. School districts operating outside this range face substantially higher per-unit costs.

High school curriculum

Figure 4 shows the average cost of the three standardized high school curriculums, assuming a student density of 1.8 transported students per square mile. It is much more expensive to provide an extensive curriculum which includes vocational courses. Minimum average costs for

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[3] Given the school district's salary schedule and investment in plant and equipment, the standard error of educational costs (derived from the sampled districts) was $32.28.

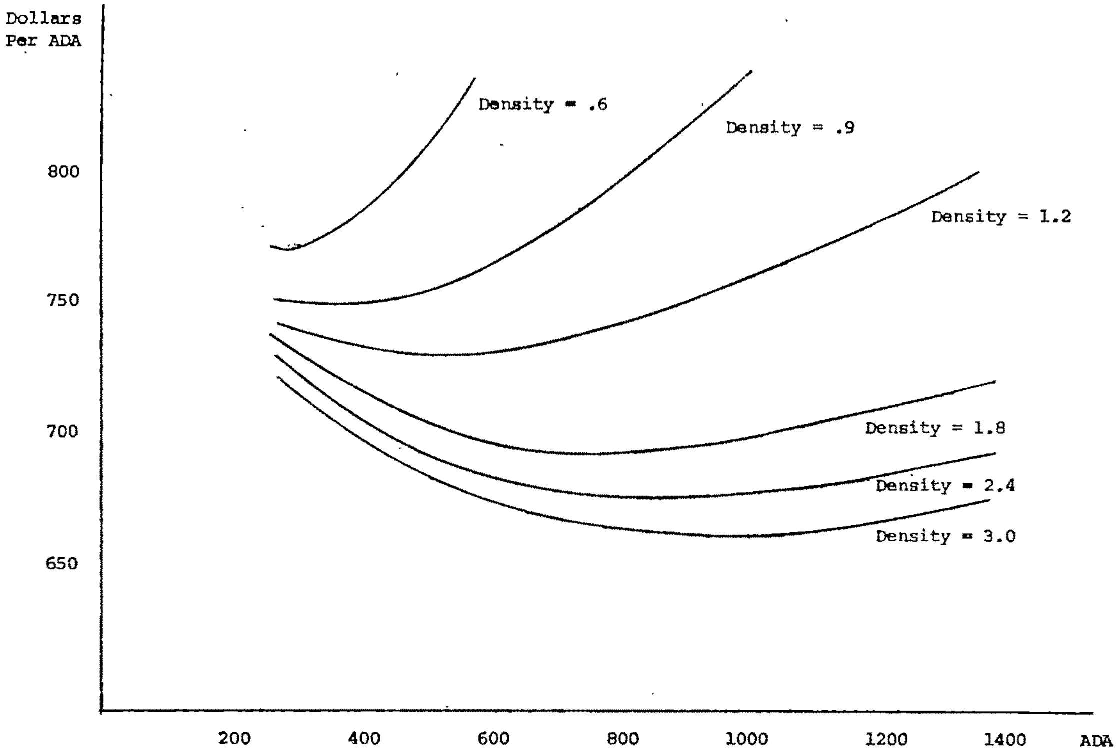

Figure 5. Average cost of education and transportation per ADA by student density

the three programs ranged from $665 without vocational courses to $700 for the desirable program. To achieve minimum average cost, the school district size increased from 550 *ADA* for the minimum program to 900 *ADA* for the desirable program.

Student density

Differences in student densities cause significant differences in school district size and average cost as shown in Figure 5. Minimum cost was $760 for a student density of .6 transported *ADA* per square mile and $660 for a 3.0 student density. The school district size ranged from 300 *ADA* with low density to 1,075 with high density. Thus, a positive relationship exists between student density and optimal school district size, i.e., the optimal school district size is smaller in sparsely populated rural areas. Also, school districts in sparsely populated areas operating outside the low-cost range face substantially higher per-unit costs.

Conclusions

An examination of a school district's long-run average cost curve provides some insight into how large the school district should be. Optimal size of the school district is defined as that which has minimum long-run average costs. The prescription for optimal economic operation, therefore, calls for the school district to combine resources in a least-cost manner so as to operate on the long-run average cost curve and to operate at the optimal size of school district in order to achieve minimum per-unit cost.

This paper has shown that differences in high school curriculum and student density cause significant differences in optimal size and minimum attainable costs. A more extensive curriculum requires larger school districts to efficiently utilize the program. In sparsely populated areas, school districts could not expand in size to take full advantage of economies in instruction because transportation diseconomies were an overriding factor. Transportation costs are not nearly as important in heavily populated districts.

Although the average long-run cost curves considered here apply to the single school year 1969–70, the basic findings are likely to remain relevant for future years. Although inflation will shift both the transportation and educational cost curves upward, the optimal size will not necessarily shift markedly to the right or left. Also, minor variations from the optimal size cause only slight increases in costs.

References

[1] COHN, ELCHANAN, "Economies of Scale in Iowa High School Operation," *J. Human Resources* 3:422–434, Fall 1968.

[2] "Cost of Construction," *School Mgt.* 14:15–35, July 1970.

[3] HANSON, NELS W., "Economy of Scale as a Cost Factor in Financing Public Schools," *Natl. Tax J.* 17:92–95, March 1964.

[4] HIRSCH, WERNER Z., "Measuring Local Services," in *Exploring the Metropolitan Community*, ed., John C. Bollents, Berkeley, University of California Press, 1961, pp. 353–368.

[5] ISARD, WALTER, AND ROBERT E. COUGHLIN, *Municipal Costs and Revenues Resulting from Community Growth*, Wellesley, Mass., Chandler-Davis Publishing Company, 1957, pp. 71–74.

[6] MINER, JERRY, *Social and Economic Factors in Spending for Public Education*, Syracuse, Syracuse University Press, 1963, pp. 93–138.

[7] OSBURN, DONALD D., "Economies of Size Associated With Public High School," *Rev. Econ. & Stat.* 52:113–115, Feb. 1970.

[8] RIEW, JOHN, "Economies of Scale in High School Operation," *Rev. Econ. & Stat.* 48:280–287, Aug. 1966.

[9] SCHMANDT, HENRY J., AND G. ROSS STEPHENS, "Measuring Municipal Output," *Natl. Tax J.* 13:369–375, Dec. 1960.

[10] WHITE, FRED C., "A Quantitative Analysis of Factors Affecting Elementary and Secondary Schooling Quality in Oklahoma with Economic Application for Rural Areas," unpublished Ph.D. thesis, Oklahoma State University, 1972.

[11] WRIGHT, WILLARD A., AND WILFRED H. PINE, *Costs of Rural High Schools in Central Kansas, 1956–57*, Kansas State Univ., Agri. Exp. Stat. Bull. 429, 1961, pp. 3–18.

The New Varieties under Dryland Conditions: Mexican Wheats in Tunisia*

MALCOLM J. PURVIS

The new wheats in the dryland conditions of Tunisia are being grown with limited success on large-scale mechanized farms. Achieving yield potentials depends on careful control of plant growth. If this is not done, traditional varieties outyield the new wheats.

DURING the early 1960's high-yielding wheat varieties were developed in Mexico at CIMMYT. These wheats (and the rice varieties developed at IRRI in the Philippines) have been the basis for the much publicized "Green Revolution" in developing countries, particularly in South and Southeast Asia [2, 6, 16]. These new varieties are all short strawed "dwarf" cereals that respond well to fertilizer application. However, they were developed for irrigated conditions. In Tunisia, as in the rest of North Africa and large areas of the Middle East, wheat production is predominantly from dry land agriculture, i.e., relies upon rainfall during the growing season. Much of these areas suffer not only from sparse average annual rainfall but also from very marked inter– and intra-seasonal variability.[1] As yet there is little experience with the high-yielding varieties in dryland conditions. Tunisia was one of the first countries to try to adapt the new wheats to rainfed agriculture.

Tunisia, once a net exporter of wheat, has over the last decade relied increasingly on imports to meet its growing internal consumption needs. To increase national wheat production, using the newly available technology, a Cereals Project was started by the Tunisian Government with the support of USAID, Ford Foundation, and CIMMYT. In 1966–1967 the first field trials were made using seed imported from Mexico. By 1970–71 just over 100,000 hectares (about 8 percent of national cereals area) were planted commercially to the new wheats with an average yield of 15 quintals per hectare [13]. Average yields in the past for traditional soft wheats[2] in Northern Tunisia have been about 8 quintals per hectare and for durum wheats only about 5 quintals [8, pp. 10, 16]. The new wheats have so far been grown successfully only by the modern mechanized sector of Tunisian agriculture. Wheeled tractor, caterpillars and combine harvesters are a regular part of wheat production in this modern sector.

During 1969–70 a small farm management survey of wheat production in the modern sector was conducted. This survey, the first of its kind in Tunisia, collected data from 27 cooperative, pre-cooperative, and state farms on which the trainees of FAO farm manager school had been placed for a year's practical experience. The data not surprisingly showed that on these farms the new wheats, with very similar costs of production (apart from increased fertilizer use), were far more profitable than the local soft and hard wheats. A 64 percent increase in the gross margin was achieved.

However, there is a danger in underestimating the difficulties faced by Tunisia in obtaining significant and continued productivity gains from the new varieties. Although the new wheats have given average yields of more than double traditional wheat yields, *under comparable conditions* the Mexican wheats are perhaps not much more than 30 percent more productive than the old varieties. In the survey reported here the average yield for traditional soft wheats was 12.8 quintals as against 17.3 quintals for the Mexican wheats—a difference of 34 percent. The wheat yields obtained by the Cereals Project's demonstration farms in 1967–68 and 1968–69 show a similar difference as do the results obtained from the FAO experimental farm at Beja over a three year period 1967–68 through 1970–71 [7, 11, 12, 13]. In brief, the existing local varieties, well adapted to Tunisian conditions and widely used over a long period of time, are also *capable* of yield levels several times higher than the national average. The problem is clearly not one of introducing new genetic potential, but of realizing the potential already available through the use of complementary inputs. Furthermore, if the new

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* The data used in this article were obtained while the author was a member of the University of Minnesota contract team in Tunisia, financed by USAID AID/afr 469.

[1] For an analysis of rainfall variability and yield variability in Tunisia see [8].

[2] The Mexican wheats are also soft wheats. They are of rather lower quality than the established soft wheat varieties in Tunisia [5, p. 22].

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varieties are extended from the small modern sector and replace the old varieties in larger areas, their *average* yields must be expected to decline (due to their use on more marginal land, with lower rainfall, capital intensity, management, etc.).

Even more significant is the evidence that in dryland areas, where the environment is more arduous, the responsiveness of new varieties to carefully exercised control may assume even greater importance than under irrigated conditions. It can be hypothesized that the new wheats under dryland conditions are far more sensitive than the established local varieties to "control" variables, those factors which affect plant growth and yields and which lie within the control of the farmer. By contrast, "noncontrol" variables are those outside the control of the farmer; examples are rainfall, some diseases,[3] and wind and hail damage. It seems reasonable to presume that plant breeding has been directed to the selection of plants less sensitive to noncontrol variables[4] and more responsive to control variables. However, the plant breeder by deliberately selecting material responsive to control inputs (e.g., nitrogenous fertilizer) may also select plants more sensitive to the *absence* of proper control. The five year experience of the Tunisian Cereals Project has time and again demonstrated the importance of seed bed preparation, seeding rates, date of planting, rate and timing of fertilizer, and weed control.[5] If this control is not purposely exercised, the local wheats may actually outyield the Mexican wheats.

The above hypothesis is supported by evidence from two sources. First, the Cereals Project demonstration farm data of 1967–68 and 1968–69 reported yields of the Mexican wheats and of Florence Aurore (a widely grown local variety) grown on the same farms and *under equal conditions of "control."* The yields of Mexican wheats are positively correlated with the yields of Florence Aurore. The slopes of the linear regression of Mexican wheat yields on Florence Aurore yields are greater than one, and for 1968–69 the intercept is negative:

Year	*Intercept*	*Slope*	R^2
1967–8	6.621	1.12 (.22)	.52
1968–9	−3.759	1.75 (.15)	.87

In other words, at low yields the superiority of the Mexican wheats is less in absolute terms than at high yield levels and may even (in the case of 1968–69) be negative. The 1968–69 data suggest that when Florence Aurore yields 5 quintals per hectare or less, the Mexican wheats will be even *less* productive.

Secondly, data from the 1969–70 survey were used to show that Mexican wheat yields are more responsive to control variables than are the traditional varieties.[6] This was done by regression analysis of yields against total cost of production[7] and against an index of control variables. Total cost of production is a measure of the degree of control being exercised. The greater the amount of tillage, seed used, or of chemical inputs, the higher the total cost of production per hectare. However, total cost is not a good measure of the quality of control; hence an index was constructed to measure better the *degree* of control being exercised. The control index included seven variables: tractor hours in seedbed preparation, date of planting, seed rate, amount of phosphatic fertilizer applied, amount of chemical weed killer used, amount of nitrogenous fertilizer applied, and timing of nitrogen application (date and whether single or split-level application). In addition, rainfall (a non-control factor but of obvious importance) was included in the analysis but as a separate variable. Each control variable was standardized so that it had a mean value of 1.0 and a lower bound of zero. The index was constructed by simple addition of the values for each variable. In the case of data for time of planting, the variable was measured by weeks away from the dates recommended by the Cereals Project.

Results of this analysis are shown in Table 1. The slope coefficients for the Mexican wheats, associated with lower intercepts, are highly significant in both cases, supporting the hypothesis that control is a major factor in obtaining high yields from them.

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[3] Some diseases, particularly seed-borne disease, could be considered as controllable factors since they can be eliminated by seed treatment and selection. Others can be diminished in importance by cultural practices. However, endemic or epidemic disease (e.g., rust and wheat blights) is outside the control of the individual farmer.

[4] Elimination of photosensitivity (day length) was a key element in the rice breeding program at IRRI.

[5] These factors have been stressed repeatedly in the reports of the Cereals Project [11, 12, 13, 14, 15].

[6] An analysis of nitrogen and rainfall on wheat yields for the demonstration farm data also found that a proxy variable for management was more significant, especially in the case of the Mexican wheats [3].

[7] Defined as the sum of the cost of variable inputs; excludes overhead costs.

Table 1. Tunisia: linear regression analysis of wheat yields, survey 1969–70

Variety (Yield in Quintals)	Intercept	Total Cost (dinars)	Index	Rainfall (millimeters)	R^2
Total Cost					
Durum Wheat	−19.58	.313 (.335)	—	.037** (.018)	.32
Traditional Soft Wheats	− 1.467	.495* (.317)	—	.025* (.015)	.39
Mexican Wheats	−12.995	.843*** (.234)	—	.011 (.018)	.61
Index of Control					
Durum Wheat	−11.793	—	3.674* (2.625)	.011 (.018)	.21
Traditional Soft Wheats	− 2.451	—	2.665** (1.133)	.010 (.012)	.54
Mexican Wheats	−37.974	—	5.839*** (2.206)	.039** (.021)	.40

* Significant at 90 percent level.
** Significant at 95 percent level.
*** Significant at 99 percent level.

Adequate control in Tunisia has only been achieved so far on the modern mechanized farms. Small farmers who tried the new wheats in 1970–71 and who did not have either the mechanical means or necessary knowledge to achieve control rejected the new wheats, and plantings in 1971–72 slumped from 100,000 hectares to 60,000 hectares. The importance of mechanical power in Tunisia for achieving control should not be underestimated. Not only is mechanical cultivation one way of assuring that cultivation operations are properly executed, but the control variables all have a very important element of timeliness—in seedbed preparation, planting, fertilizer and herbicide applications, harvesting. Because of the dependence on natural rainfall, the time periods in which these operations must and can be performed, even using mechanical power, are very limited. For example, the period between onset of the rains and the time when it is too late or impossible to continue cultivation because of waterlogged soils is frequently very short. Similarly there is risk in delaying harvest due to sirocco winds causing lodging and shattering. In any event technology for achieving control without the use of mechanical power has not yet been developed in Tunisia.

In conclusion, the increased productivity of the new short strawed wheats in dryland conditions in Tunisia has been about one third greater than for the existing established varieties. High average yields (of double national average yield) obtained on relatively small acreages are not grounds for optimism for rapid future increases in productivity. Control over plant growth rather than genetic potential appears to be the limiting factor in Tunisia. To date this control has only been achieved with (expensive) mechanical cultivation in the modern sector. Unless the new seeds can be adapted to the resource conditions of the traditional nonmechanized small farmer sector, further productivity growth will require large-scale investment in (imported) machinery and consolidation of small farms into larger units suitable for mechanized farming. If the Tunisian experience is any guide, the green revolution under dryland conditions may be slower and even more costly economically, socially, and politically than under irrigated conditions for which the new varieties were originally developed [cf. 1, 4, 9, 10].

References

[1] ABEL, MARTIN E., "The Distribution of Agricultural Development Gains in India: A Case Study for South and Southeast Asia," in *Externalities in the Transformation of Agriculture: The Distribution of Benefits and Costs from Development*, Iowa State University, (forthcoming).

[2] BARKER, RANDOLPH, "Green Revolution," *Current Affairs Bulletin* 45:66–79, Jan. 1970.

[3] BEN SENIA, MOHAMED, "Comparison of Yields of Wheat Varieties in Tunisia," Department of Agricultural and Applied Economics, University of Minnesota, April 1971, mimeo.

[4] COWNIE, JOHN, BRUCE F. JOHNSTON, AND BART DUFF, "The Quantitative Impact of the Seed Fertilizer Revolution in West Pakistan: An Exploratory Study," *Food Research Institute Studies in Ag. Econ., Trade and Development* 9:57–95, 1970.

[5] DAHL, R. P., "International Trade and Price Prospects for Cereals and Their Implications to Tunisia," Dept. of Agr. and Applied Econ. Staff Paper Series, University of Minnesota, Nov. 1971.

[6] FALCON, WALTER P., "The Green Revolution: Second-Generation Problems," *Am. J. Agr. Econ.* 52:698–722, Dec. 1970.

[7] Food and Agricultural Organization of the United Nations, "Experimentation et Demonstration sur Certaines Productions Fourrageres et Animales," *Tunisie: Production de Ble dans les Centres d'El Afareg et de Bou Rebia*, AGS: SF/TUN 17, Rapport Technique 5, Rome, 1971.

[8] HYSLOP, J. D., AND R. P. DAHL, "Production de Ble en Tunisie: Tendances et Variabilités," *Rapport de Recherche en Economie Agricole No. 1*, Ministere de l'Agriculture, Tunis, May 1970.

[9] JOHNSTON, BRUCE F., AND JOHN COWNIE, "The Seed Fertilizer Revolution and Labor Force Absorption," *Am. Econ. Rev.* 59:569–582, Sept. 1969.

[10] LELE, UMA J., AND J. W. MELLOR, "Jobs, Poverty and the Green Revolution," *International Affairs* 48:20–32, Jan. 1972.

[11] Tunisia, Republic of, Secretariat of State for Agriculture, *Resultats de la Premiere Campagne d'Introduction des Bles Mexicains en Tunisie*, mimeo, July 1968.

[12] ———, *Resultats des Demonstrations de Production de Ble de la Campagne 1967–68 avec le Secretariat d'Etat a l'Agriculture de Tunisie et la Mission Speciale de Cooperation Economique et Technique des Etats-Unis d'Amerique*, (hecto, no date).

[13] ———, *Farm Experience with Short Stemmed Mexican Bread Wheat Varieties During 1968–1969*, Accelerated Cereals Production Project, (hecto, no date).

[14] Tunisia, Republic of, Ministry of Agriculture, Project pour l'Augmentation de la Production des Cereales, *Rapport Annual 1970–71*, (no date).

[15] ———, *Rapport Semis: 1970 et 1971* (mimeo, no date).

[16] WHARTON, CLIFTON R., "The Green Revolution: Cornucopia or Pandora's Box?" *Foreign Affairs* 47: 464–476, April 1969.

Extension Education in Bargaining among Midwest Livestock and Grain Producers*

HAROLD D. GUITHER

Midwest grain and livestock producers show substantial interest and support for bargaining to improve prices received, but they are less willing to participate in control of volume and orderly marketing efforts to make bargaining effective. However, agricultural bargaining offers an opportunity for creative educational efforts among these producers.

SURVEYS show that midwest livestock and grain producers are not entirely satisfied with present marketing and pricing systems. Some look at bargaining as a possible means of improving the price received for their commodities. But when faced with the responsible decisions that they must make to accompany successful bargaining, it looks less attractive [2, 3, 5].

This situation poses a dilemma for Extension economists faced with carrying out educational efforts. But the problems are not insurmountable. Experiences with single meetings from 1969–1971 and a pilot bargaining short course in Illinois in February 1972 may provide some guidelines for others contemplating Extension programs.

The Illinois experiences indicate that educational materials on bargaining prepared by the North Central Regional Committees in Marketing and Public Policy can be used effectively in Extension programs on bargaining among livestock and grain producers.

Introductory exposure to principles of bargaining was carried out at various locations across the state from 1969–1971 using the North Central Extension Marketing Committee slide set "Farmers and Bargaining Power." One-night meetings created an awareness of economic principles involved and for those seriously interested served as a brief introduction for in-depth study.

Pilot short course sessions consisted of five successive meetings one week apart, each approximately two and one half hours long. Farmers from three counties met at a central location on a community college campus. The format was based on North Central Extension Publication 30, *Bargaining in Agriculture—Potentials and Pitfalls in Collective Action* [1], the 1970 Illinois farmer surveys [3], and local area speakers who could contribute to the program.

In each session time was provided for Extension economists to make a presentation in the first half and for guest speakers to talk and answer questions during the second half. A coffee and doughnut break in the classroom midway through each session provided a needed shift in the program and opportunity for farmer participants to visit together.

Guest speakers contributed their own specialized knowledge and provided new faces to stimulate and maintain interest in the program. They were carefully selected and advised what they were to talk about. Included among the guest speakers were a panel of livestock marketing practitioners—a firm representative, a livestock buyer, and a livestock cooperative fieldman engaged in contract marketing—who discussed their roles in pricing; the contract manager for Caterpillar Tractor Company and the president of the local United Auto Workers union at Caterpillar who discussed labor contract negotiations; and representatives of two farm organizations, Farm Bureau and NFO, who presented their views on bargaining.

The 50 farmers who registered paid a small registration fee to cover local expenses and maintained attendance of 90 percent or more at each session. Although participants ranged in age from 23 to 67, the average of 41.6 years was considerably below the state average of 49 years [6].

Two state Extension economists and a district marketing specialist handled the major teaching responsibilities and local coordination. County Extension advisers assisted with registration and promotion. A local coordinator is essential to arrange for speakers and handle other on-site program details. In a pilot effort, two Extension economists can evaluate the program more effectively than just one.

Keeping the participants involved stimulated

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their interest and encouraged a high attendance each week. Involvement was achieved by a series of information surveys and stimulating and provocative speakers who frequently made the question and answer period the most exciting part of the program.

The surveys served two distinct purposes. First, they provided a picture of farmer participants' attitudes about bargaining and their knowledge of economics. Second, they provided a teaching tool for the instructors.

Three surveys taken at separate sessions were tabulated and reported to the class on the following weeks. The "Bargaining Attitude Test" of nine questions revealed general feelings about bargaining, prices, and marketing. The "Pricing and Negotiations" survey described hypothetical situations and offered a multiple choice so participants could show how they would react to these developments as members of a bargaining committee. The "Role of Government" survey was a brief multiple choice form with four questions that covered foreign trade policies, eg., dealing with Communist countries and pricing products to remain competitive in foreign trade. On the last night of the class, an evaluation questionnaire was used to obtain constructive suggestions for future bargaining short courses and to determine if the participants had changed their general attitudes toward bargaining.

The surveys showed the following farmer attitudes toward bargaining; they are generally supported by earlier surveys [2, 4] among representative groups of Illinois and Missouri farmers:

1. A large majority felt that bargaining is generally desirable to give farmers a stronger voice in pricing their products. Most were still convinced of this need after five weeks of study and discussion. However, three of the 50 participants (6 percent) said bargaining had no place in agriculture, while none of them gave this response at the beginning of the course.

2. Farmers do not agree on how they will make bargaining work. Among the short course participants, 43 percent felt farmers could organize and run their own associations, 46 percent said farmers should organize but would need help from government to enforce the rules, and 11 percent said neither would work.

3. Attitudes of both grain and livestock producers show a substantial support for bargaining in principle, but less willingness to participate in the control of volume and orderly marketing efforts that would make bargaining effective. In both the short course and the earlier state wide survey [4], more farmers indicated interest in bargaining than were willing to hold grain off the market until asked to deliver or to send livestock to market in specified numbers and weights in compliance with a bargaining agreement.

Table 1. "Fair" prices for 1972 as viewed by Illinois Extension short course participants

Commodity	Low	High	Average of all responding	Average Illinois farm price February, 1972
Corn (per bu.)	$ 1.20	$ 2.68	$ 1.46	$ 1.09
Wheat (per bu.)	1.40	3.50	2.01	1.42
Soybeans (per bu.)	2.50	4.00	3.19	3.04
Hogs (100 pounds)	22.50	34.00	26.65	25.70
Choice steers (100 pounds)	24.00	48.00	35.47	34.00[a]
Milk (Grade A per 100 pounds)	5.00	8.00	6.13	6.20

[a] Average price, all steers and heifers.

4. Obtaining widespread acceptance of a negotiated price may be an obstacle in future bargaining efforts for livestock and grain farmers. The short course participants gave a wide range of responses about what they considered a fair price for major farm commodities (Table 1). With this wide range, agreeing upon a price to ask and a price to accept in the negotiating process could be a major problem in group bargaining efforts.

5. For group bargaining to be possible, the majority of producers must belong to the bargaining association, must be willing to let their bargaining representatives make price decisions, and must accept the final negotiated price and terms of sale. The traditional freedom for each individual operator to make his own decisions about when he will sell and what price he will accept may be another major obstacle to widespread acceptance of bargaining by grain and livestock producers.

In conclusion, agricultural bargaining offers a potential opportunity for creative educational efforts but also involves risks of error and misunderstanding. A grain buyer for a major processor refused to participate as a guest speaker because he believed the Extension Service was attempting to organize farmers to demand higher prices.

The difference between education on the alternatives and consequences of actions that producers might take and actual organization efforts can be easily misunderstood. The role of

Extension economists should be education. Policy decisions and action programs belong with farm organizations and producer groups.

Working with 50 farmers in a bargaining short course reveals that many do not understand the complex nature of bargaining, the functions of prices and pricing systems, elasticity of demand, the legal aspects of price negotiations, and the discipline required for effective group action. Before extensive collective bargaining efforts among livestock and grain farmers will be feasible, both legislation and an intensive educational effort among all farm operators will be needed.

References

[1] BREIMYER, HAROLD F., ed., *Bargaining in Agriculture—Potentials and Pitfalls in Collective Action*, North Central Regional Extension Publication 30, University of Missouri Extension Division C911, June 1971.

[2] DRISS, SADOK, AND HAROLD F. BREIMYER, "Opinions of Leading Missouri Farmers About Farm Policy," in *Economic and Marketing Information for Missouri Agriculture*, Department of Agricultural Economics, University of Missouri-Columbia, Nov. 1971.

[3] GUITHER, HAROLD D., AND M. B. KIRTLEY, *Bargaining Power for Illinois Farmers*, Dept. of Agr. Econ. Coop. Ext. Service EQ4, University of Illinois, Dec. 1970.

[4] GUITHER, HAROLD D., "Illinois Farmers View Current Policy Issues," *Illinois Agricultural Economics* 10–11: 23–31, July 1970–Jan. 1971.

[5] HATHAWAY, DALE E., RICHARD L. FELTNER, JAMES D. SCHAFFER, AND DENTON MORRISON, *Michigan Farmers in the Mid Sixties*, Agr. Exp. Sta. Res. Rep. 54, Michigan State University, Aug. 1966.

[6] U. S. Department of Commerce, Bureau of the Census, *Census of Agriculture*, Illinois, 1970.

Graduate Programs in Agricultural Economics: Results of a Survey

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A 1970 mail survey of U. S. and Canadian agricultural economics departments attempted to identify new approaches to graduate education. Areas explored included program objectives, requirements, and procedures. Some evolutionary changes in specific requirements and procedures were identified, although few revolutionary changes in orientation were discovered.

As a part of the departmental graduate review process at the University of Massachusetts, a mail survey was conducted of other agricultural economics departments in the U. S. and Canada to solicit information about new insights and innovative approaches to graduate education in the field. This article presents some results of the survey.

The questionnaire was mailed in the fall of 1970 to the heads or chairmen of 58 U. S. and Canadian academic departments with graduate programs in either agricultural economics or closely related fields. Usable returns were received from 48 departments. Seventeen offered only the Master's degree, and 31 offered both the Master's and Ph.D. degrees. Questionnaires were completed by department heads or departmental graduate program directors.

Objectives of Agricultural Economics Graduate Programs

An open-ended question at the beginning of the questionnaire asked, "What are the educational objectives of your department's (a) Master's degree program and (b) Ph.D. program?" Responses were quite varied in depth and approach. Since a number of caveats relevant to quantification of answers to such a general question may be stated, only a broad quantification of response categories is presented (Table 1).

Master's degree programs tended to have more diverse, specific objectives than did Ph.D. programs. The objective of developing expertise in economics and quantitative analytical methods was the only one mentioned frequently for Ph.D. programs. Master's program objectives commonly related to future activities anticipated for the students—either further graduate work for the Ph.D. or specific types of employment.

A fairly large number of administrators of graduate programs in our field appeared to find it difficult to articulate the objectives of their programs. About one-fifth of the respondents either did not answer the question or referred to attached handbooks or policy statements which often did not contain any useful statements about program objectives. Some of those who did state objectives were vague or gave incomplete answers.

The departments were asked whether objectives had changed significantly in the last five years. Nearly half the respondents answered "yes" with respect to Master's programs, and about one-fourth did likewise for the Ph.D. However, descriptions of changes appended to the affirmative answers in most cases referred to program procedures such as the requirement of more theory or quantitative courses or changes in exam procedures. The most frequent change

Table 1. Major categories of educational objectives for Master's degree and Ph.D. programs in agricultural economics and closely related fields, as expressed by department heads and graduate program directors

Educational Objective Category	Percent of respondents stating objectives in each category[a]	
	Master's Degree Program	Ph.D. Program
Pre-Ph.D. training	50	—
Training or preparation for careers in specified fields or activities	54	29
Training in economics and quantitative analytical methods	54	68
Stimulation of individual development and program flexibility to accommodate individual needs	27	19
No objectives stated[b]	19	29

[a] The total number of respondents was 48 for Master's degree programs and 31 for Ph.D. programs.

[b] No answer or answers indicated objectives were not stated.

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Table 2. Courses added to and dropped from agricultural economics graduate curricula in the last five years[a]

Type of course	Number of departments which have dropped a course of this type	Number of departments which have added a course of this type
Quantitative methods[b]	2	34
Resource economics[c]	2	27
Economic development[d]	—	16
Economic theory[e]	1	15
World agriculture and trade	2	12
Regional development and analysis	—	12
Agricultural marketing[f]	17	12
Agricultural business management	2	10
Agricultural policy[g]	2	8
Agricultural production economics and farm management	4	3
Other	7	8

[a] A total of 46 respondents answered this question.
[b] Includes econometrics, operations research, programming and research methods.
[c] Includes water resource economics.
[d] Includes agricultural development.
[e] Includes micro and macro-theory, mathematical economics and welfare economics.
[f] Includes cooperative marketing and commodity marketing under courses dropped only. Includes general marketing, market organization and transportation under both categories.
[g] Includes seminars on topics of current concern.

in objectives reported at the Master's level was implied by the addition of a terminal or nonthesis program specifically designed to train students for business or other careers.

Graduate Program Requirements in Agricultural Economics

Graduate courses and course programs

Specific questions were not asked about courses required in graduate programs since others have done that fairly recently.[1]

One question asked was whether new courses had been added to or dropped from the graduate curriculum (courses offered) in the last five years, or if any courses had been substantially revised. Responses classified by subject matter area are shown in Table 2.

In addition to substantial increases in quantitative methods offerings, rather definite changes in emphasis are suggested. In general, changes in graduate course offerings appear to reflect: first, an increasing emphasis on nonagricultural domestic problems, such as resource development and regional development; problems at the macro level; and international problems; and second, a decreasing emphasis on traditional domestic agricultural problems, particularly commodity-focused marketing and production problems of the firm (although there is some increase in agribusiness management training).

Graduate examinations

Thirty of the 31 departments offering the Ph.D. indicated they used written preliminary examinations. The other department explained that students' committees usually administered a written examination.

Stated objectives of the written preliminary examinations varied among departments. In decreasing order of frequency, the objectives mentioned were: (1) to test the student's knowledge (chiefly theory and quantitative methods), (2) to test the student's ability to apply knowledge to problems, (3) to test the student's general competence or ability, (4) to test his ability to continue in dissertation research, and (5) to serve as an aid to the student's development by inducing him to integrate his knowledge.

Another question was included: "Are you satisfied with written preliminary comprehensive examinations as a method for determining if a student should be admitted to Ph.D. candidacy?" Thirty respondents answered the question—16 affirmatively, 13 negatively, and one with a "yes" and "no."[2] The following question—"If no, do you have any suggestions for improvement?"—elicited no suggestions for an alternative evaluative device. Respondents felt, however, that the written exam should not be the sole criterion and that oral exams, class performance, etc., should also be taken into account.

Theses

All Master's degree students were required to write theses in 19 of 45 responding departments. Another 19 required theses of more than half of their students, and seven did not require a thesis.[3] Interestingly, 63 percent of the departments offering only Master's degrees required theses of all Master's students, while only 31 percent of departments offering both graduate degrees required all Master's students to write theses. Generally, students who did not write theses submitted a special petition to justify exclusion, and this was used in making a decision along with the student's background and/or objectives. Although a number of departments offered both thesis and nonthesis options, only eight differentiated the titles of degrees received by students. Graduate assistants were required to write theses in most departments as conditions of their employment.

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[1] Cramer and Sokoloski surveyed Ph.D. students in 29 agricultural economics departments during the school year 1964–1965 and reported their findings in this journal [1]. More recently, J. W. Parlour of the University of Manitoba conducted a 1970 survey which covered 22 U. S. and Canadian agricultural economics programs [2].

[2] One department indicated that class performance admits the student to candidacy and the preliminary examination is only a test, not a criterion for candidacy.

[3] These figures understate the proportion of departments with nonthesis options, since the first group of 19 included

When screening potential Ph.D. students, 30 respondents stated they would be more critical of students with nonthesis Master's degrees, one indicated he would reject such a student, and 16 indicated that it would make no difference. An interesting additional fact to consider is that 23 of the 29 Ph.D. granting departments which answered the question indicated that they permitted students with a B.S. to enter directly into a Ph.D. program (although six of the 23 said that they discouraged this practice). Thus, for most of these departments, a Master's thesis does not seem to be a prerequisite for a Ph.D. program. The evidence obtained from these questions indicates a dichotomy in thinking within the profession about the value of the Master's thesis.

Respondents to a question of whether a paper suitable for publication (but not necessarily published) would be an acceptable substitute for a Master's thesis were evenly split—22 would accept such a paper and 22 would not.

One of the problems associated with the thesis/dissertation requirement is that a fairly large number of students finish their graduate course work (and examinations in the case of Ph.D. students) but for reasons of financial pressure, etc., leave before their theses or dissertations are completed. In the average department responding, 13 percent of the Master's students and 21 percent of the Ph.D. students were in this category. The percentage of students never finishing was estimated to be less than five for Master's students and less than four for Ph.D. students.[4]

Table 3. **Proportion of agricultural economics department graduate students who receive teaching and/or extension experience in their graduate programs**

Proportion of students who receive the experience	Percent of departments in category[a]			
	Teaching		Extension	
	Master's degree	Ph.D.	Master's degree	Ph.D.
None	34	3	69	46
1–9	21	14	20	25
10–19	21	30	7	25
20–49	7	27	4	4
50–95	15	23	—	—
100	2	3	—	—
	100	100	100	100

[a] Forty-seven respondents answered the question for teaching—Master's degree, 30 for teaching—Ph.D., 45 for extension—Master's degree, and 28 for extension—Ph.D.

Teaching and extension experience

There are very few departments where a significant portion of students receive teaching experience and only one where all receive it (Table 3). A very small proportion of students in agricultural economics receive extension experience as part of their graduate programs.

Of the respondents, 9 of 44 and 26 of 41 at the Master's and Ph.D. levels, respectively, felt all graduate students should have teaching experience. Suggestions included teaching entire courses (most felt these should be lower-level undergraduate courses), conducting lab or discussion sessions, conducting seminars, substituting for absent faculty members, serving as teaching apprentices to faculty members, and taking education or teacher training courses. Many respondents indicated an appreciation of the value of teaching experience but were perplexed as to how it could be effectively incorporated in graduate programs within the field.

Changes in Agricultural Economics Graduate Programs

"Has your department made any innovative changes in the graduate program during the last five years or are any innovative changes currently under serious consideration? If yes, please describe them." This question was answered affirmatively by two-thirds of the respondents,

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two with nonthesis options that apparently were never exercised and two more that were in the process of adding a nonthesis option.

[4] It should be noted, however, that about one-third of the departments did not state how many Ph.D. students failed to finish, some because their programs were relatively new, but some apparently because of confusion about the term "never." Also, one-fifth did not answer this question for Master's students.

although some respondents indicated uncertainty about how revolutionary a change needed to be in order to be classified as "innovative." The major types of changes indicated were as follows (the number of respondents mentioning the change is indicated in parentheses):

1. Elimination of the Ph.D. foreign language requirement (11)
2. Addition of new types of Master's degree programs, usually nonthesis options (10)
3. Revision of Ph.D. preliminary comprehensive examination procedures (8)
4. Revision in M.S. written examination procedures (3)
5. Addition of new areas, or changes in emphasis in areas (6)
6. Addition of new courses (5)
7. Changes in course requirements (6)
8. More teaching experience for students (2).

It is apparent that agricultural economics departments as a rule have eagerly exercised the option of dropping the Ph.D. foreign language requirement whenever possible, and that this is one of the more significant changes that has occurred in agricultural economics Ph.D. programs.[5]

A few specific additional changes will be mentioned here. One department instituted seminars for Ph.D. students who had completed their regular course work in order to give specific training for the Ph.D. preliminary examinations. Another department designated faculty as teams responsible for graduate course offerings in areas such as development, marketing, etc., to avoid any adverse effects from faculty turnover, leaves, etc. The same department instructed its faculty to redirect course emphasis to application of theory toward agriculturally related problems and to avoid duplication of theory. Another department identified development of more multidisciplinary thesis research problems as an innovation.

A final question asked, "Are there any changes that you would make in the graduate program if you were free of university or graduate school restrictions? Please describe, no matter how wild they may seem." The most prevalent response was that graduate school rules did not hinder changes but permitted a great deal of flexibility. Changes suggested dealt with such things as admission requirements, titles for nonthesis degrees, and graduate credit for undergraduate courses. Most frequently mentioned was the Ph.D. foreign language requirement, which apparently still exists in some schools.

A few other ideas were mentioned: making the final Ph.D. oral examination a public lecture rather than an exam; permitting a wider range of publication format than requiring theses for all student research projects; permitting greater flexibility in assignment of graduate assistants to varied duties in teaching, research, and extension; and offering separate degrees for teaching-oriented students and for foreign students.

In general, significant new directions or approaches were not discovered in the survey. Perhaps there are new developments which the survey questionnaire simply failed to unearth. However, there seems to be a growing need for substantive innovation in educational programs at all levels. Agricultural economics is not immune to the growing chorus of questions from students and society about the relevance of university teaching and research. Reactions of the profession to new social forces and values, in graduate programs as well as in other activities, will have much to do with society's judgment of the profession's worth in the decade of the 1970's.

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[5] Tolley and Grubb reported that in 1962–63, 28 of 29 agricultural economics departments required two foreign languages, with a little more than half of them permitting mathematics or other substitutes [3, pp. 194–195]. Although not specified, we assume the substitution was usually permitted for one language only. Parlour's study eight years later reported that of 18 departments, 12 required no foreign language and six required one [2].

References

[1] Cramer, Gail L., and Adam A. Sokoloski, "Ph.D. Programs in Agricultural Economics in the United States," *J. Farm Econ.* 48:738–745, Aug. 1966.

[2] Parlour, J. W., Unpublished materials on a survey of 22 graduate programs in agricultural economics, Department of Agricultural Economics, University of Manitoba, 1970.

[3] Tolley, G. S., and H. W. Grubb, "Mathematics and Statistics in Graduate Agricultural Economics Training," J. *Farm Econ.* 47:189–206, May 1965.

An Approach to Research on Vertical Coordination: The Beef System in Oklahoma*

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Analysis of selected subsystems of the Oklahoma beef marketing system reveals conflicts and inconsistencies in basic interstage relationships. Such conflicts and inconsistencies block realization of higher degrees of interstage or interlevel coordination. Improvement will require a research orientation which isolates such barriers and estimates their impact on system participants.

MARKETING research has not been without criticism. During the past two decades critical pleas for a change in orientation have appeared. A move toward a "systems approach" has been the favorite suggestion.

Kohls was calling in the 1950's for ". . . an attack on marketing systems as a whole" [3, p. 1602]. In 1962 Eldon Smith noted the lack of research effort in agricultural marketing ". . . which takes into account the totality of relevant relationships and interrelationships" [7, p. 1536]. The same theme was apparent in recommendations of the Southern Marketing Research Committee in 1963 [8]. In 1968 Shaffer argued that ". . . the major payoff (to research) is in understanding the interfirm and intermarket relationships" [6, p. 45]. At the 1971 AAEA annual meeting Godwin and Jones concluded that while a systems-oriented approach is needed, progress in this direction has been "with glacial slowness" [2, p. 813]. Either the critics are wrong or there are reasons why changes in orientation have not evolved.

Barriers to Change

There are at least two possible reasons why change has not occurred more rapidly. One deals with intensity of the felt need for change, the second with magnitude of the needed change or adjustment.

There is basis for an hypothesis that the marketing economist's failure to adjust his research orientation will permit the demise of the traditional exchange system. But this is an untested hypothesis and critics are just beginning to hammer at this theme. Godwin and Jones note the ". . . increasing proclivity and capability for coordination and control in both vertical and horizontal directions" [2, p. 807]. Breimyer has emphasized that the exchange system is only one among several kinds of systems and lamented the ". . . failure to recognize that an integrated relationship between farmers and their markets is not just a version of an exchange system but its replacement" [1, p. 940]. In general, however, the marketing economist has paid little attention to any relationship between the prevailing research orientation and gradual but persistent changes in the organizational structure of food and fiber marketing systems.

In addition to the failure to recognize the need for reorientation is the tendency to overestimate the nature and magnitude of the change which is needed. For more effective analysis of the problems in many of the marketing systems, a change in perspective which focuses increased attention on the interstage relationships may be all that is needed. It is at the merging of two stages or "levels" of activity that the exchange process is involved. It is on the interstage dimensions of the system that the marketing economist must focus his attention if the ills of the exchange system are to be cured.[1] The purpose of this paper is to promote increased dissatisfaction with procedures that place too little emphasis on, or ignore completely, the important interrelations inherent within all marketing systems.[2]

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[1] The researcher need not make a decision as to what organizational structure is "best" to be concerned with the inefficiencies of the prevailing system. Such concern will help assure that changes in organizational structure over time will be orderly, will more nearly serve the interests of all concerned, and will be the result of conscious thought and choice.

[2] Fortunately, not all marketing researchers have been oblivious to the needed changes. Work now being completed or under way at several land grant institutions demonstrates recognition of the need to look at either the systems or the interrelated processes which make up marketing systems. The "Hog-Pork Sector Study" by ERS and cooperating universities and the SM-41 regional project, which will analyze alternative systems of vertical coordination for the livestock marketing system in the South, both demonstrate recognition of some of the fundamental problems. Hopefully, this somewhat critical appraisal will speed and otherwise facilitate the needed change.

A Suggested Approach

A "new" orientation and related methodology have been employed in analysis of the Oklahoma beef marketing system. Although further testing and more empirical grounding are needed, the approach appears to have potential.

The Oklahoma beef marketing system was divided into subsystems. Once an appropriate subsystem[3] was defined, attention was directed to developing a methodology which would identify economic relationships of importance to interlevel (or vertical) coordination.

The approach employed was to select, based on *a priori* knowledge, dimensions which might affect the realized degree of interlevel coordination. Selection of each dimension was equivalent to hypothesizing that decision processes and/or actions along that dimension affect the likelihood of achieving interlevel coordination.

Once established, the hypotheses were tested in a qualitative fashion by using "mirror image" questioning procedures. Decision makers at different levels were questioned about activities along the same dimension but in terms of the perspective from which each operates.

Analyses have been completed for two subsystems within the Oklahoma beef marketing system. The producer-feeder and the feeder-packer subsystems have been analyzed to identify goal conflicts and/or operational inconsistencies and infer the impact of such conflicts and/or inconsistencies on the degree of interlevel coordination achieved by the Oklahoma beef marketing system.

The producer-feeder subsystem[4]

Among the dimensions investigated were overall goal of operation, timing of the movement of feeder cattle, and valuation of the feeder animal. Other dimensions were investigated, but these three will suffice for illustrative purposes.

Two separate questionnaires were composed. The producer was questioned as a producer and seller of an output, the feeder as a user and buyer of an input—the feeder animal being the output or input in the respective cases. Stratified random samples of 46 producers and 46 feeders were surveyed using structured personal interview techniques.

Overall goal of operation

Most producers felt they produced a raw material for use at the feeding level and not a "finished product" to suit their own preference patterns. Conversely, a majority of the cattle feeders felt the producer pays little or no attention to the type of input needed or preferred by the feeder. Related questions confirmed the apparent conflict. When asked to indicate what type of animal they tried to produce, most producers selected heavily finished feeder animals without top gain potential. Both picture series and written questions were used in the two questionnaires and the conflict was verified.

Theoretically, the price mechanism would correct such an inconsistency by awarding premiums and/or levying discounts. But the survey results suggest that corrections have not been made. The theoretically desired alignment between the output of the producer and the input needs of the feeder does not now exist. There appears to be a need to cut corners and go to the root of the problem, the basic conflict in operating goals, if the situation is to be corrected. But much of the current research activity deals with more observable dimensions of marketing performance, and the underlying goal conflict persists.

Timing of movement

The importance of a stable and timely flow of cattle into the feedlot has long been reported by the marketing economist. Yet, a significant faction of the producer group could see no reason why the feeder should worry about keeping a stable flow of cattle into the feedlot.

Within the group of producers who indicated they realize a steady flow of cattle is important to the feeder, most would require a price significantly above the break-even price to move cattle to the feeder early, weighing 650 pounds rather than a previously agreed upon 700 pounds. The "mirror image" question to the feeders indicated many would not pay the break-even price but would offer some lower price.

Much of the research in this area has focused on measurements of supply instability and related price variability. Response to the surveys suggests such variability is the observable result of a more deeply rooted problem. Price variability is tolerated because the producer is not really concerned about variability in the flow of feeder cattle. The feeder, in turn, is not willing to "share" the gains accruing from scheduled movement of feeder cattle into his lot. There is theoretical basis for suggesting increased coordination would be mutually beneficial, but research to demonstrate such benefits is not available.

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[3] By an "appropriate subsystem" is meant a set of two or more interrelated parts of the total system which exhibit the important characteristics of the total system.

[4] For more detailed discussion of the methodology which was developed and an in-depth treatment of the results refer to the M.S. thesis by Rathwell [5].

Valuation of product

A number of questions and the use of pictures of three carefully selected feeder animals[5] led to an important conclusion: there are significant differences of opinion between the feeder and producer groups as to what characteristics give value to the feeder animal. Most feeders want "stretch" or frame and not much finish; most producers opt for the more heavily finished animal.

Within the producer sample, the subgroup comprised of stocker operators[6] exhibited much closer agreement with feeders in indicating which factors give value to the feeder animal. Most respondents in this group indicated they sell directly to cattle feeders; most of the cow-calf operators indicated they sell through auctions or dealers. One can hypothesize the stocker gets a "signal" through direct contact that the exchange process has not been able to convey to the cow-calf operator.

Grades have long been a popular area of research. But the prevailing lack of agreement on what constitutes a valuable feeder animal leads to a most uncomfortable conclusion: the feeder animal has *not* been described and priced in a manner which has transmitted clear and discernible price signals to Oklahoma producers. The result is a continued lack of alignment between the output of the producer and the input needs of the cattle feeder—a continued lack of interlevel coordination.

The feeder-packer subsystem[7]

Three of the more important dimensions investigated were overall goal of operation, level versus variability in returns (or costs), and strategies on provision of information. The two-questionnaire approach was used. Stratified random samples of 42 feeders and 23 packers were surveyed.

Overall goal of operation

Both feeders and packers were asked to select from among alternative goals which differed on the basis of maximizing net returns versus stabilizing net returns at an acceptable level, and length of planning horizon. Most cattle feeders, especially the larger feeders, indicated they attempt to maximize returns to each lot of cattle they handle.[8] Conversely, most packers noted they attempt to maximize returns over a longer period of time, usually an operating year.

The difference in length of planning horizons is important. The feeders' operating goals would permit, perhaps accentuate, short-run price fluctuations. Faced with a relatively high fixed-to-variable cost ratio, the packer may be forced to bid up prices during periods of short supply.

Lack of coordination extends beyond the legitimate buyer-seller conflict. The price mechanism appears to be reactive to the prevailing situation and has not functioned effectively in the corrective role the theory affords to price. Research results which demonstrate the prevailing inconsistency and the possible implications of selected changes in operating procedures are needed.

Level versus variability in returns (costs)

Selecting from alternative sales patterns, the feeders indicated a preference for the more variable patterns if average net returns increased significantly with the variability. In a related question, however, a significant number of the feeders selected the more variable patterns even though average net returns were held constant.

The "mirror image" question to the packers probed their willingness to pay for increased stability in the flow of cattle into their plants. More than half of 21 responding packers indicated they would prefer a procurement pattern with average costs at $30.20 per cwt. and a maximum variation in cattle numbers of 2 percent around the preferred operating level to other patterns with an average cost as low as

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[5] Three feeder animals grading choice and weighing 650 pounds were selected on the basis of frame and degree of finish. It was assumed the animal with frame (large skeletal structure) and a low degree of finish would be the better input for the cattle feeder.

[6] The 12 of 46 "producers" who owned no cows and who bought light calves to carry on grass or wheat pasture until they reached feedlot-ready weights were termed "stockers" in the study.

[7] For more detailed treatment of the analysis involving this subsector refer to Purcell and Dunn [4].

[8] The custom feeder who feeds cattle for others would be expected to adopt a policy of maximizing returns to each lot of cattle. Many of the noncustom feeders also adopted such a position, however.

$29.80 but with variability ranging up to 9 percent.

More investigation and better measurement are needed, but it would appear that a feeder might well receive a premium for working with the packer in scheduling movement of cattle, and that packers recognize the cost implications of fluctuating supplies of cattle and indicate some willingness to share potential benefits. Research results to demonstrate the level and possible distribution of such benefits are conspicuous in their absence.

Strategies on provision of information

The feeders were asked to indicate how much information they would prefer to make available to the buying packer before beginning negotiations. Alternatives ranged from simply making the cattle available for inspection to providing complete information on previously fed cattle, including information on dressing percentage, quality grade, and yield grade.

Eighteen of 41 responding feeders would do no more than make the cattle available for inspection. The packers' response to the related question indicated not all packers would trust the detailed information if offered. Other packers, however, indicated they would either not bid on the cattle at all or try to impose a price discount (up to $1.00 per cwt. or more) when such information is not provided by the feeder.

The importance of equally well-informed buyers and sellers has long been voiced by the economist. Although much has been written about the need to discount for uncertainty, the message on these and related ramifications of the negotiation process has failed to reach most Oklahoma cattle feeders and many of the meat packers. Lack of information on important value-related product attributes can lead to inconsistencies between negotiated price and "true product value." More evidence is needed on the size and nature of such possible pricing errors and the cost-returns implications of those errors to both feeder and packer.

Conclusions

A change in research orientation by the agricultural marketing economist is badly needed. Analysis of selected subsystems in the Oklahoma beef marketing system reveals conflicts and inconsistencies in the most basic interstage or interlevel relationships. Such conflicts and inconsistencies undermine operation of the exchange system and prevent price from functioning effectively as an allocative and corrective device. Attention on these barriers to interlevel coordination, not on the observable behavior of the system, is what appears to be needed. Meeting these needs means "systems research" or, at a minimum, an orientation that acknowledges existence and importance of interlevel behavioral relationships as the primary determinant of the realized degree of coordination along the vertical dimension of any marketing system.

References

[1] BREIMYER, HAROLD F., "Future Organization and Control of U. S. Agricultural Production and Marketing," *J. Farm Econ.* 46:930–944, Dec. 1964.

[2] GODWIN, MARSHALL R., AND L. L. JONES, "The Emerging Food and Fiber System: Implications for Agriculture," *Am. J. Agr. Econ.* 53:806–815, Dec. 1971.

[3] KOHLS, R. L., "A Critical Evaluation of Agricultural Marketing Research," *J. Farm Econ.* 39:1600–1609, Dec. 1957.

[4] PURCELL, WAYNE D., AND T. L. DUNN, "Economic Implications of Goal Conflict and Operational Inconsistency in the Feeder-Packer Sector of the Beef Marketing System," *Proceedings*, Western Ag. Econ. Assoc., 1970, pp. 38–46.

[5] RATHWELL, P. JAMES, "Economic Implications of Interlevel Goal Conflict and Operational Inconsistency in the Beef Marketing System: The Producer-Feeder Subsector," unpublished M.S. thesis, Oklahoma State University, 1972.

[6] SHAFFER, JAMES D., *A Working Paper Concerning Publicly Supported Economic Research in Agricultural Marketing*, Washington, D. C., ERS, USDA, March 1968.

[7] SMITH, ELDON D., "Discussion: Goals and Conflicts in Agricultural Marketing Research," *J. Farm Econ.* 44: 1533–1536, Dec. 1962.

[8] Southern Marketing Research Committee, *A Framework for Marketing Research in the South*, a report prepared for distribution to market researchers in the South, Aug. 1963.

Summing Components of Real Capital Gains*

H. B. HUFF AND T. G. MACAULAY

The rationale for using homogenous categories of assets for estimating capital gains in agriculture has not been fully recognized. Data from two recent studies illustrate the sizeable discrepancies between summing regional versus national aggregate capital gains estimates. In addition, information is generated about regional disparities in distribution of capital gains.

CAPITAL gains from U. S. farm assets have been estimated in several studies including Bhatia [1], Boyne [2], Grove [3], Hathaway [4], and Hoover [5]. All of these authors recognized the value of calculating capital gains by type of asset, but only Boyne provided estimates of capital gains by region. The purpose of this paper is to demonstrate that the summation of regional values for capital gains provides a more accurate estimate of the national total. In a similar way, the summation by type of asset provides a more accurate estimate of the overall gain than those made from data undifferentiated by type of asset. Ideally, calculation should be made using homogenous regions and assets—homogenous in the sense that price and quantity changes are the same for the asset or region.

Regional summation of capital gains is the simplest to illustrate, and Boyne's study will be used for this purpose. His study gives annual estimates of real capital gains during 1940–1960 for farm real estate. These are calculated for all of the U. S. (aggregate method) and also for the 10 economic regions (component method). The differences in the results between these two methods were attributed by Boyne to the different values used for the constant dollar series [2, p. 56]. In this note it is shown that this is incorrect. While part of these differences obviously does lie with the data, another important factor in using a capital gains formula like that employed by Boyne is that the regional or component sums cannot equal the national (or aggregate) total, except under either of two very restrictive conditions.[1]

These restrictive conditions can be demonstrated by using a two-region country. Let:

$a_{i,t}$ be the current dollar value for region i, in year t, and

$b_{i,t}$ be the constant dollar value for region i, in year t, where i is 0 for the country, 1 for region one, 2 for region two.

Further, current dollar values and constant dollar values for the two regions are equal to the country total, i.e.,

$$a_{0,t} = a_{1,t} + a_{2,t} \tag{1}$$

$$b_{0,t} = b_{1,t} + b_{2,t}. \tag{2}$$

Using Boyne's formula [2, p. 33], the nominal capital gains (NCG) are:[2]

$$\begin{aligned} NCG_i = {} & (a_{i,t+1} - a_{i,t}) \\ & - \frac{1}{2}\left[a_{i,t}\left(\frac{b_{i,t+1}}{b_{i,t}} - 1\right) \right. \\ & \left. + a_{i,t+1}\left(1 - \frac{b_{i,t}}{b_{i,t+1}}\right)\right]. \end{aligned} \tag{3}$$

The sum[3] of the regional estimates is:

$$\begin{aligned} NCG_1 + NCG_2 = {} & (a_{1,t+1} + a_{2,t+1}) \\ & - (a_{1,t} + a_{2,t}) \\ & - \frac{1}{2}\left[a_{1,t}\left(\frac{b_{1,t+1}}{b_{1,t}} - 1\right) \right. \\ & + a_{2,t}\left(\frac{b_{2,t+1}}{b_{2,t}} - 1\right) \\ & + a_{1,t+1}\left(1 - \frac{b_{1,t}}{b_{1,t+1}}\right) \\ & \left. + a_{2,t+1}\left(1 - \frac{b_{2,t}}{b_{2,t+1}}\right)\right]. \end{aligned} \tag{4}$$

Therefore, the sum of the regional estimates, ($NCG_1 + NCG_2$), is equal to the country total (NCG_0) only if the following condition holds:

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* The authors wish to acknowledge the helpful suggestions provided by B. B. Perkins and an anonymous *Journal* reviewer.

[1] Bhatia [2, p. 502] outlines two additional formulas for estimating capital gains which are equivalent to that employed by Boyne. The results of our analysis apply equally well to each formula.

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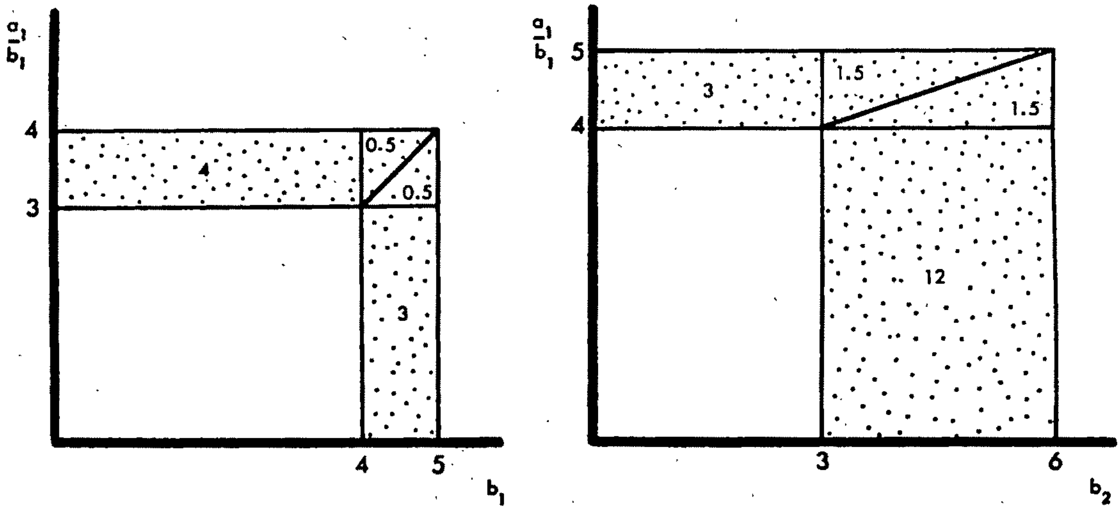
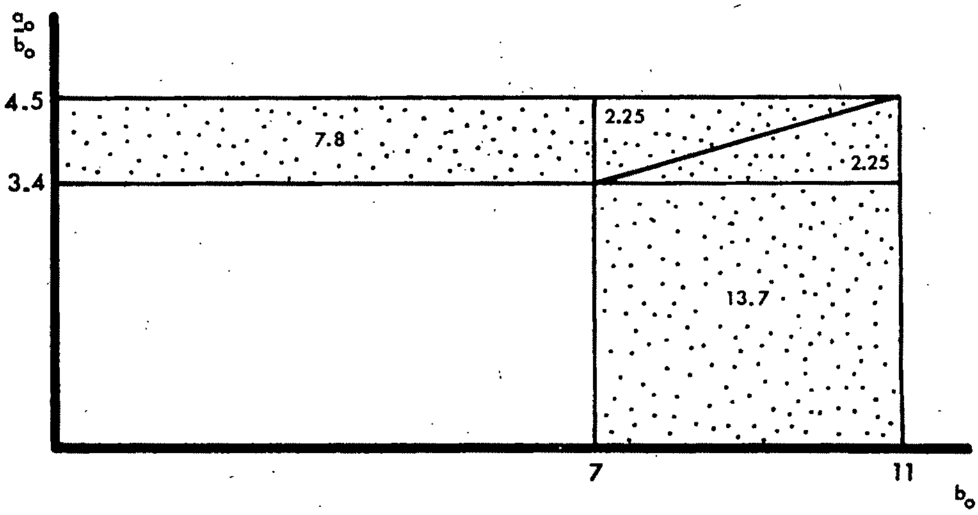
[2] Nominal capital gains are easily converted to real capital gains and are used here for simplicity.



Region 1

Region 2



Country

Figure 1. Price and quantity changes for the two regions and the country

$$\left(\frac{a_{1,t}b_{1,t+1}}{b_{1,t}} + \frac{a_{2,t}b_{2,t+1}}{b_{2,t}}\right) - \left(\frac{a_{1,t+1}b_{1,t}}{b_{1,t+1}} + \frac{a_{2,t+1}b_{2,t}}{b_{2,t+1}}\right) = \left(\frac{a_{0,t}b_{0,t+1}}{b_{0,t}}\right) - \left(\frac{a_{0,t+1}b_{0,t}}{b_{0,t+1}}\right); \tag{5}$$

or stated more simply, if the following conditions hold:

$$\frac{b_{0,t+1}}{b_{0,t}} = \frac{b_{1,t+1}}{b_{1,t}} = \frac{b_{2,t+1}}{b_{2,t}}, \text{ or} \tag{6}$$

$$\frac{a_{0,t}}{b_{0,t}} = \frac{a_{1,t}}{b_{1,t}} = \frac{a_{2,t}}{b_{2,t}}. \tag{7}$$

These restrictions require that either the ratio of the constant dollar value from one year to the next be the same in each region as in the country as a whole or the ratio of current to constant dollars (the price) be the same in each region as in the country as a whole.[3] These are very limiting assumptions and are unlikely to occur except by chance.

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[3] A similar proof of these restrictions is employed by Boyne to state conditions under which there are unbiased price and quantity components for each time period.

A graphical illustration with numerical examples may further clarify the reasons for these discrepancies. Figure 1 shows the two-region example given the following:

$$a_{1,t} = 12,\ a_{1,t+1} = 20,\ a_{2,t} = 12,\ a_{2,t+1} = 30,$$
$$b_{1,t} = 4,\ b_{1,t+1} = 5,\ b_{2,t} = 3,\ b_{2,t+1} = 6.$$

It can be seen that the sum of the shaded areas for region 1 and region 2, which are the differences in current dollar values between period t and $t+1$, are the same as that for the country. However, the sum of the price component in the regions is $(4+0.5)+(3+1.5)=9.0$, which is less than that for the country, $(7.8+2.25)=10.05$. It can also be shown that if the conditions indicated in equations (6) and (7) hold, these areas would be equal.

To show the size of the discrepancy between the aggregate and component methods if the above restrictions are not fulfilled, the authors recalculated the regional capital gains using the same data as Boyne but with an aggregate approach (i.e., regional farm real estate values were summed before the capital gains were estimated). The results are shown in Table 1. Boyne attributes the differences between column (1), his aggregate approach, and columns (3) and (5), his component approach (use of individual regions), to differences in the constant dollar data he used. It is shown in columns (2) and (4) that with use of the *same* data but a different approach, the results sometimes diverge to an even greater extent. It should be noted that this discrepancy is a minor issue in the bulletin by Boyne and does not detract from the rest of his study.

Table 1. Real wealth gains from farm real estate comparing aggregate data and regional sums using three estimates of the stock of U. S. farm real estate, billions of 1910–1914 dollars

Five-Year Periods	USDA[a]	Method A[b]		Method B[c]	
	Aggregate (1)	Aggregate[d] (2)	Sum of regions[e] (3)	Aggregate[d] (4)	Sum of regions[e] (5)
1940–44	2.15[f]	2.64	2.52	1.84	1.69
1945–49	−1.04	−0.97	−1.06	1.62	1.54
1950–54	4.18	3.87	3.95	5.11	5.08
1955–59	7.12[f]	7.64	7.82	7.91	8.21

[a] The USDA constant dollar series [7] was used.

[b] A perpetual inventory technique for farm buildings was used in developing a constant dollar series for farm real estate.

[c] A deflated current dollar technique for farm buildings was used in developing a constant dollar series.

[d] Authors' calculations based on aggregate data from Boyne [2, p. 54, Table 16].

[e] From Boyne [2, p. 55, Table 17].

[f] These values differ slightly from those shown in Boyne [2, p. 39, Table 11], as a result of our disagreement with values estimated for 1943, 1944, and 1959, as shown in [2, p. 36, Table 9].

Table 2. Real capital gains from farm assets for Canada and the provinces, 1947–1966

Year	Canadian Total	Sum of Provinces	Difference
	million dollars		
1947	−345.2	−347.6	2.4
1948	−70.7	−84.9	14.2
1949	423.0	407.6	15.4
1950	387.8	362.7	15.1
1951	−507.5	−542.6	35.1
1952	264.2	239.8	24.4
1953	−89.1	−124.8	35.7
1954	−110.1	−157.8	47.7
1955	69.6	66.1	3.5
1956	−163.1	−206.8	43.7
1957	284.1	245.8	38.3
1958	227.5	265.8	−38.3
1959	233.1	221.3	11.8
1960	93.9	134.8	−40.9
1961	278.2	285.9	−7.7
1962	291.8	285.2	6.6
1963	695.9	515.7	180.1
1964	655.4	690.2	−34.8
1965	718.5	830.6	−112.1
1966	877.9	846.5	31.4

Source: Huff and Cusack [6, p. 15, Table 3].

The results from a similar Canadian study of capital gains [6] which provides annual differences between the aggregate and component (provincial) sums demonstrate this discrepancy more clearly (Table 2). Annual differences of up to 25 percent were observed, with the component sums, on average, less than the aggregate (Canadian) total. The largest differences between these two methods occur when price or quantity changes deviate widely in the individual regions. These two examples emphasize the importance of estimating capital gains for a homogenous region, particularly for real estate, which dominates farm capital gains. The same argument can also be made for using a classification of assets which groups only similar types of assets.

In addition to the marked improvements in capital gains estimates from using homogenous regions and assets, considerably more information is available on the distribution of capital gains. In the Canadian study (Table 3), for example, there are regions which obviously did not share in capital gains from Canadian agricultural assets. This information is important for the development of appropriate agricultural and regional economic policies.

It is difficult to make meaningful U. S.—

Table 3. Total real capital gains from Canadian farm assets, by province, 1947–1966

Province	Livestock and poultry	Implements and machinery	Crop inventories	Farm real estate	Total	Total as percent of net farm income[a]
	mil. 1966 dollars[b]					percent
Canada	208.0	−167.9	−134.0	4,532.5	4,438.5	13
Prince Ed. Is.	−3.4	−10.5	−0.2	6.7	−7.4	−3
Nova Scotia	−5.1	−7.0	−0.1	12.2	−0.1	0
New Brunswick	−3.3	−11.1	−0.2	11.3	−3.3	−1
Quebec	−22.0	−254.7	−2.5	106.6	−172.6	−4
Ontario	0.7	−82.0	−3.8	1,279.8	1,194.7	15
Manitoba	13.4	−1.4	−7.3	368.5	373.2	12
Saskatchewan	32.9	142.4	−70.8	1,336.7	1,441.2	17
Alberta	20.1	36.0	−43.1	1,077.1	1,090.2	18
British Columbia	2.3	−3.3	−0.7	163.3	161.6	11

[a] Data from Dominion Bureau of Statistics, "Net Income of Farm Operators from Farming Operations," *Farm Net Income*, Catalogue #21-202.

[b] In 1966 dollars using the Consumer Price Index as a deflator.

Source: Huff and Cusack [6, pp. 17–20].

Canadian comparisons of capital gains because of differences in data definitions and collection procedures as well as in the objectives and time periods between studies. Three common characteristics do emerge, however. First, farm real estate is consistently the most important component of real capital gains. Second, regional variations in capital gains are substantial. Third, while capital gains produce a significant addition to total farm welfare, instability of farm income is increased as a result.

In summary, the reasons for divergent results between the component and aggregate approaches have been identified, and the value of estimating capital gains for homogenous groups of assets and regions has been emphasized. If capital gains are to be used as an element in assessing welfare levels in the farm sector, it is essential to use procedures which provide the best estimates possible.

References

[1] BHATIA, KUL B., "On Estimating Capital Gains in U. S. Agriculture," *Am. J. Agr. Econ.* 53:502–506, Aug. 1971.

[2] BOYNE, DAVID H., *Changes in the Real Wealth Position of Farm Operators 1940–60*, Mich. State Univ. Tech. Bull. 294, 1964.

[3] GROVE, E., "Farm Capital Gains—A Supplement to Farm Income?" *Agr. Econ. Res.* 12:37–42, 1960.

[4] HATHAWAY, D. E., "Agriculture and the Business Cycle," *Policy for Commerical Agriculture—Its Relation to Economic Growth and Stability*, U. S. Congress Joint Economics Committee, 85th Cong., 1957.

[5] HOOVER, DALE M., "Real Capital Gains in U. S. Agriculture 1940–59," *J. Farm. Econ.* 44:929–940, Nov. 1962.

[6] HUFF, H. B., and T. J. CUSACK, *Capital Gains from Farm Assets in Canada, 1946–66*, Publication AE/72/1, School of Agricultural Economics and Extension Education, University of Guelph, 1972.

[7] U. S. Department of Agriculture, *Balance Sheet of Agriculture*, Agr. Infor. Bull. No. 232, Washington, U. S. Government Printing Office, 1960.

Estimation of Irrigation Response from Time-Series Data on Nonirrigated Crops

D. W. PARVIN, JR.

Innovations in equipment have created interest in irrigation in the humid areas of the United States. However, decisions on the economic feasibility of irrigation are hindered because information on irrigation response is not available. A technique is presented (with empirical application) which approximates irrigation response from time-series nonirrigated data.

IDEALLY, data to investigate crop response to irrigation would come from irrigated versus nonirrigated experimental plot data replicated over several years so that average weather for the region under study would be represented and other factors influencing yield would be held constant. Such data are not available for most regions and crops. This paper presents a technique approximating irrigation response from time-series data on nonirrigated crops and summarizes an empirical application.

Procedure for Estimation of Irrigation Response

A series of data on yields through time can be viewed as a function of weather and trend [1]. The meaning attached to trend depends upon the data utilized. Estimation of irrigation response and its distribution requires that the data be complete for a sufficient period of time to represent the climate of the region under study.

Estimation of irrigation response from time-series nonirrigated data requires the assumptions that: ideal weather[1] occurred at least one year in the data set; irrigation has the same effect on yield as ideal weather;[2] and factors influencing yield other than weather may be measured by trend. If perfect weather occurred, additional water would not have been applied even if irrigation equipment had been available. Ideal weather was assumed to occur in the year when weather had its largest positive effect on production. The estimated trend or technology line adjusts reported production for technology and average weather. Deviations from the technology line measure the weather effect. The maximum weather effect is used to adjust the technology line for ideal weather.

Figure 1 and Table 1 explain the procedure for a simplified five-year example. In the hypothetical example 5, 10, 8, 15, and 12 units are the observed levels of production for five consecutive years. Consider the line $\hat{Y}_t=4+2t$ as the technology line. This line adjusts for technology and average weather. The deviations -1, 2, -2, 3, and -2 represent the size of the weather effect by year. The maximum positive weather effect was 3 units which occurred in year t_4. Ideal weather (especially rainfall and its distribution) was assumed to have occurred that year. Had average weather occurred, the level of production would have been 12 units rather than the observed 15 units. Hence, the difference between average and ideal weather was 3 units. Since the irrigation response was assumed to have the same effect on yield as ideal weather, the 3 units were also viewed as the irrigation response with average weather. Since $L_1(\hat{Y}_t=4+2t)$ reflects technology with average weather, L_2 defined as $(\hat{Y}_t+\max_t[Y_t-\hat{Y}_t])$ or $(\hat{Y}_t+3)$ for the example reflects technology with ideal weather. And, the difference between L_2 and the observed level of production is the increase that would have resulted had irrigation been practiced in the tth year.

In year t_1 weather had a negative effect on production. Actual production was five units whereas estimated production due to technology and average weather was 6 units. The irrigation response estimation technique estimated irrigated production at 9 units. Hence, the estimated additional production that would have resulted from irrigation in year t_1 was (9–5) or 4 units, i.e., estimated response to irrigation in year t_1 was 4 units. In year t_2 weather had a positive effect on production. Weather increased yields from the estimated level of 8 units due to technology and average weather to 10 units. Estimated production with irrigation was 11

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[1] Ideal weather as interpreted here represents conditions that give maximum yields for the crops grown.

[2] This assumption implies that irrigation removes all yield variability due to weather. Such an assumption will overestimate the magnitude of the irrigation response since other weather variables such as temperature are known to influence yield.

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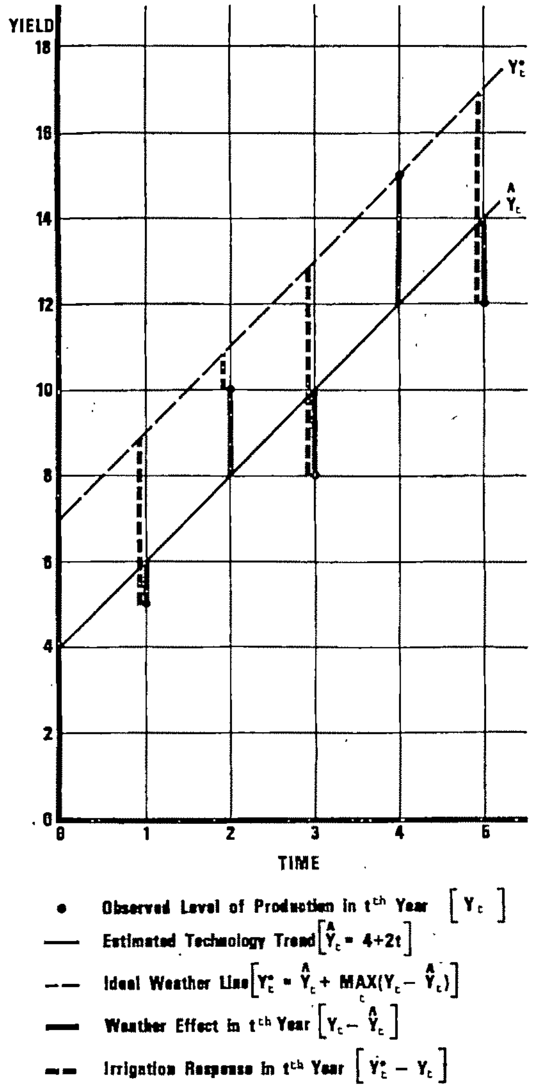

Figure 1. Hypothetical graph indicating estimated technology trend, ideal weather, weather effect and irrigation response

units. Therefore, the estimated irrigation response in the year t_2 was (11–10) or 1 unit. In year t_4 the estimated irrigation response was zero.

Application to Selected Crops in the Georgia Coastal Plain

Until recently most irrigation in the Georgia Coastal Plain was done by hand-moved, lightweight aluminum pipe capable of watering two to three acres at one setting. Due to the large amount of hand labor required to move the pipe, the limited acreage covered in a season, and the relative high per acre investment cost, irrigation was not profitable to use except on high value crops such as tobacco and vegetables.

Recently, however, large irrigation systems designed for rolling terrain with relatively low per acre cost have created new interest in irrigation. Consequently, information is needed on the economic feasibility of irrigating crops for which irrigated versus nonirrigated data are not available in sufficient quantities to estimate the response to irrigation and its distribution.

Sources of data

Production data utilized were average county yield per acre for peanuts and corn for 60 counties in the Georgia Coastal Plain for the period 1954–1969.[3] Values reported by the Georgia Crop Reporting Service [3] were used.

Fullilove [2] conducted a study on irrigation cost for the Georgia Coastal Plain in 1969. The results are summarized in Table 2. Total cost per acre of use decreases as utilization of the system increases. There is also an inverse relationship between total cost per acre of use and size of system. The costs reported are average values observed. Actual costs for a given farm vary depending upon the availability and cost of insuring an adequate water supply.

Results

The irrigation response estimation technique was applied to each of the 60 counties, and results were averaged to obtain approximate values for the region under study. Increase in yield due to technology was estimated by linear trend. Changes in all cultural, nutritional, and management practices were as-

Table 1. Hypothetical example indicating irrigation response estimation procedure[a]

t	Y_t	$\hat{Y}_t$	$Y_t-\hat{Y}_t$	$\max_t(Y_t-\hat{Y}_t)$	Y_t^{*b}	$Y_t^*-Y_t$
1	5	6	−1		9	4
2	10	8	2		11	1
3	8	10	−2		13	5
4	15	12	3	3	15	0
5	12	14	−2		17	5

[a] t = year.
Y_t = Observed level of production in t_{th} year.
$\hat{Y}_t$ = Estimated production adjusted for technology and average weather in t_{th} year.
$Y_t-\hat{Y}_t$ = Weather effect in t_{th} year.
Y_t^* = Production adjusted for technology and ideal weather (irrigation) in t_{th} year.
$Y_t^*-Y_t$ = Irrigation response in t_{th} year.
[b] $Y_t^* = \hat{Y}_t + \max_t(Y_t-\hat{Y}_t)$.

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[3] Average county yields per acre were the only data of sufficient length to represent the climate of the Georgia Coastal Plain.

sumed to be represented by trend. Least squares estimates of the annual change in yield due to technology (trend) for farms in the study area were 80.15 pounds and 1.91 bushels per acre for peanuts and corn,[4] respectively.

Estimated average irrigation responses for peanuts and corn in the study area are reported in Table 3. On the average, irrigation was estimated to increase yields of peanuts by 326.29 pounds and corn by 14.58 bushels per acre. However, the average response is highly variable as indicated by the standard deviations and coefficients of variability.

Table 2. Annual irrigation cost per acre of use for self-propelled pivot system, Georgia Coastal Plain, 1969[a]

Size of System		Utilization[b]		
		1.0	1.7	2.0
(Acres)		dollars		
50	Fixed cost per acre			
	Interest	20.50	12.05	10.25
	Depreciation[c]	47.93	28.18	23.97
	Taxes and Insurance	2.07	1.22	1.03
	Total fixed	70.50	41.45	35.25
	Variable cost per acre[d]			
	Repairs	2.16	2.16	2.16
	Labor[e]	0.53	0.53	0.53
	Fuel	4.75	4.75	4.75
	Total variable	7.44	7.44	7.44
	Total Costs	77.94	48.89	42.69
100	Fixed cost per acre			
	Interest	16.46	9.68	8.23
	Depreciation	38.48	22.63	19.24
	Taxes and Insurance	1.66	0.98	0.83
	Total fixed	56.60	33.29	28.30
	Total variable	7.44	7.44	7.44
	Total Costs	64.04	40.73	35.74
150	Fixed cost per acre			
	Interest	12.42	7.30	6.21
	Depreciation	29.03	17.07	14.52
	Taxes and Insurance	1.25	0.74	0.62
	Total fixed	42.70	25.11	21.35
	Total variable	7.44	7.44	7.44
	Total Costs	50.14	32.55	28.79
200	Fixed cost per acre			
	Interest	8.38	4.93	4.19
	Depreciation	19.58	11.51	9.79
	Taxes and Insurance	0.84	0.49	0.42
	Total fixed	28.80	16.93	14.40
	Total variable	7.44	7.44	7.44
	Total Costs	36.24	24.37	21.84
250	Fixed cost per acre			
	Interest	4.33	2.55	2.16
	Depreciation	10.13	5.96	5.07
	Taxes and Insurance	0.44	0.26	0.22
	Total fixed	14.90	8.77	7.45
	Total variable	7.44	7.44	7.44
	Total Costs	22.34	16.21	14.89

[a] Costs were developed by J. R. Allison (associate professor of agricultural economics, University of Georgia Experiment Station, Griffin, Georgia) from Fullilove [2] and other secondary sources.

[b] Utilization refers to acreage irrigated. The value 1.0 indicates that the acreage irrigated equals size of system. The average utilization of self-propelled pivot systems observed by Fullilove [2] was 1.7.

[c] Depreciation based on 10 year life.

[d] Variable costs reported are annual averages.

[e] Labor valued at $1.50 per hour.

Table 3. Estimated average irrigation response and value per acre for peanuts and corn, Georgia Coastal Plain, 1954–1969[a]

Crop	Average response per acre	Value Price[b] high	medium	low
Peanuts	329.29[c] (210.61) [64.55]	48.94	39.15	29.37
Corn	14.58[d] (8.49) [58.23]	19.68	17.50	15.31

[a] Average based on 57 counties and 16 years (N=912) for peanuts. Average for corn based on 60 counties and 16 years (N=960). Parentheses enclose standard deviations and brackets enclose coefficient of variability.

[b] Prices were .15, .12, and .09 $/lb. for peanuts and 1.35, 1.20, and 1.05 $/bu. for corn.

[c] Pounds.

[d] Bushels.

Economic Feasibility

The value of the estimated average irrigation response must exceed average irrigation cost for the system to be economically feasible. Tables 2 and 3 are appropriate for such comparisons.

Peanuts

For price equal to $.15 per pound and level of utilization equal to 1.0, the analysis indicated that irrigation was economically feasible for systems of 200 acres or larger. When the level of utilization increases to 1.7 or 2.0, economic feasibility was indicated for all systems examined.

For price equal to $.12 per pound and level of utilization equal to 1.0, results were the same as for price of $.15 per pound. For level of utilization equal to 1.7, the analysis indicated that irrigation was economically feasible for systems of 150 acres or larger. For level of utilization equal to 2.0, all systems analyzed except the 50 acre size or less were economically feasible.

For price equal to $0.09 per pound and level of utilization equal to 1.0, only the largest system appeared to be economically feasible. For level of utilization equal to 1.7, the results indicated that systems as large as 200 acres or larger were economically feasible. When the level of utilization was increased to 2.0, economic feasibility was indicated for systems of 150 acres or larger.

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[4] Estimates obtained by pooling all county data by crops weighted by percent of production for area that the county represented.

Corn

For price equal to $1.35 per bushel and level of utilization equal to 1.0, none of the systems analyzed were economically feasible. For level of utilization equal to 1.7 or 2.0, only the largest system was economically feasible. For price equal to $1.05 per bushel, only the largest system with level of utilization equal to 2.0 was economically feasible.

Summary and Limitations

Methodology was developed suitable for preliminary analysis of available data approximating irrigation response from time series nonirrigated yield data. Average county yield data for the general period 1954–1969 was used to estimate the effect of technology and irrigation on yields of peanuts and corn for the Georgia Coastal Plain. In that specific area, the estimated annual change in yield due to technology was 80.15 pounds for peanuts and 1.91 bushels for corn per acre.

The estimated average irrigation response in the study area was 326.29 pounds per acre for peanuts and 14.58 bushels for corn. However, the average response was highly variable for both crops. Preliminary analysis indicated that irrigation of peanuts appeared to be economically feasible for larger systems, higher levels of utilization, and higher prices, and that irrigation of corn did not appear to be economically feasible in the Georgia Coastal Plain.

Use of county average yield data underestimates the yield variability of individual farms. Hence, the irrigation response estimation technique tends to underestimate the irrigation response.[5] This underestimation is offset somewhat by the overestimation resulting from violation of the assumption that irrigation has the same affect on yield as ideal weather, i.e., that irrigation removes all yield variability due to weather. For purposes of the Georgia Coastal Plain study, the difference in the two effects was assumed not to be critical to the results.

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[5] The larger the variability of the series, the greater the maximum deviation and the greater the difference between the ideal weather line and the estimated technology trend line (see Fig. 1).

References

[1] DOLL, JOHN P., "An Analytical Technique for Estimating Weather Indexes from Meteorological Measurements," *J. Farm Econ.* 49:79–88, Feb. 1967.

[2] FULLILOVE, W. T., "Self-Propelled Tower Irrigation Average Costs and Returns," Georgia Exp. Sta. Res. Rep. 96, University of Georgia, 1971.

[3] Georgia Crop Reporting Service, *Georgia Agricultural Facts*, selected issues.

Sparse Data, Climatic Variability, and Yield Uncertainty in Response Analysis*

Jock R. Anderson

A method based on smoothing sparse data is developed for assessment of risk in crop response processes when only few data are available. An empirical example illustrates how optimal inputs depend on degree of risk aversion when controlled inputs influence risk.

AGRICULTURAL response analysts have traditionally given only cursory attention to yield uncertainty in their assessment of efficient allocation of variable resources and have concentrated on *ex post* appraisal of response experiments. Exceptions have employed game-theoretic approaches [13, 18] and, most recently, techniques featuring some elements of decision theory such as probability [5, 9, 12, 17] and mean-variance (E–V) analysis [3, 11].

A frequent difficulty of accounting for environmental risk on the basis of response experiments lies in finding an appropriate sequence of observations over a time span of sufficient length to indicate yield variability. This paper presents a method of assessing risk with sparse data and abstracts from uncertainties in factor and product markets. The empirical illustration, like most related work on this topic, pertains to crop response to fertilizer.

An Approach to Measuring Response and Risk

Colyer [3] has illustrated some of the shortcomings of using "average" response functions for perennial recommendations on fertilizer use and has noted the irrelevance of *ex post* optima for individual seasons in *ex ante* decision making. Response to inputs like fertilizer is seldom certain due to the influence of uncontrollable factors such as rainfall and temperature, and consequently producers face a risky decision in selecting input rates. Good risky decisions should be based first on an assessment of response and its riskiness and second on the producer's attitude to income and risk. If useful forecasts of the uncertain factors are available, these too should impinge on the decision, but this possibility is not treated here [2, 7].

The scheme outlined below presumes the availability of a few (n) sets of experimental response data in a location defined as reasonably homogeneous in measurable features of the environment such as rainfall, soil type, available nutrients, etc. For simplicity, the scheme is outlined initially for sparse response data from a single site, and subsequently an indication is given of how the scheme could accommodate data from several sites. Data are defined here as "sparse" when they are too few to enable adequate functional analysis of probability distributions of yields, either by direct means [3, 4, 8, 11] or indirectly through specification of the effects of stochastic factors with known probability distributions [5]. That is, the approach now suggested is recommended for risky response analysis when conventional procedures fail through paucity of data.

Six steps are included in the scheme, but the core of the method (Step 3) consists of smoothing sparse data. It is proposed to use Schlaifer's [16, p. 104] rule that: "If a sample of n observations is drawn from some distribution and arrayed in order of size, the p-th observation is a reasonable estimate of the $p/(n+1)$ fractile of the distribution." A smooth cumulative distribution function (CDF) curve can then be graphed through the fractile estimates. The rule is nonparametric and is "reasonable" in the sense that the expected fraction of the population falling below the pth order statistic is $p/(n+1)$ [15, p. 405].

The suggested steps are:

1. For each set of data, find a least-squares response function that is (hopefully the most) acceptable in terms of the conventional variety of statistical and bioeconomic criteria. Not all of the k-controlled variable inputs may appear in each of the n functions with nonzero coefficients.
2. Use each of the n selected "best" response functions to predict output levels for the design points of a convenient and adequate experimental design for the k controlled inputs. This might

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be, for example, a 4^k complete factorial or corresponding composite design straddling a range of inputs similar to that included in the original response experiments.

3. For each design point, rank the n predicted outputs, apply Schlaifer's fractile estimation rule, and hand-smooth a graphical CDF incorporating any additional information such as the non-negativity of output and the fact that distributions are likely to be unimodal [4, 16].[1]

4. Use each empirical CDF to estimate the first few moments of the yield distribution at each design point. This can be done either directly by taking expectations with a considerable number of discrete probability elements from the CDF or indirectly by fitting Pearson curves [4, 10].

5. Use least squares regression to fit the derived moments and any other pertinent distributional features, such as the median, as functions of the controlled inputs or decision variables:

$$
\begin{aligned}
E(Y) &= f_e(X_1, X_2, \cdots, X_k), \\
V(Y) &= f_v(X_1, X_2, \cdots, X_k), \\
&\vdots \\
M_j(Y) &= f_j(X_1, X_2, \cdots, X_k),
\end{aligned}
\tag{1}
$$

where the X_i, $i=1, \cdots, k$, denote the controlled inputs, $E(Y)$ denotes the mean response, $V(Y)$ denotes the variance of response, and $M_j(Y)$ denotes the jth central moment. These functions should be selected primarily on statistical criteria such as goodness of fit, reliability of coefficients, and apparent consistency with the least-squares assumptions.

6. The final step consists of obtaining the producer's preference function for risk defined in terms of the first few moments of the distribution of net profits (π) and using this to determine the input rates that maximize his preference or utility. Specification of preference in terms of moments can be rationalized via a Taylor series expansion of a preference function for profit [6, p. 26]. The number of moments to assess in the analysis depends on the magnitudes of the corresponding derivatives of the preference function but, as a practical matter, only a few moments (say, 2 to 4) usually need be considered, e.g., $U=U[E(\pi), V(\pi), M_3(\pi)]$.

Magnusson [14] has elaborated how optimal rates of the decision variables, X_i, are determined by solving simultaneously the partial derivative equations, $\partial U/\partial X_i=0$, $i=1, \cdots, k$. In contrast to his didactic examples, the present more general specification of risk typically leads to solution of nonlinear systems of equations. Relative to Step 6, Colyer's [3] approach of maximizing $E(\pi)$ with respect to the X_i subject to constraints on the level of $V(\pi)$ can be viewed as a partial accounting for risk that avoids specifying the producer's preference for risk.

It should be noted that some degree of smoothing is involved in Step 1 as well as in Step 3. To the extent that within-period variation contributes to final crop yields, the procedure accounts for the effects of within-year and between-year sources of risk. As sample size increases, the $E(Y)$ function will approach the "average" function estimated by simply pooling all the original data. The method proposed is concerned primarily with assessing risk.

Assuming that uncontrolled random factors such as rainfall are fairly homogeneous in each experimental period, the approach can be generalized to accommodate the situation where experiments at several or many sites are conducted with the intention of incorporating site variables so that conditional response can be determined. This generalization can be described most succinctly by means of a flow chart (Fig. 1). The two methods indicated as preferable alternatives to the suggested "sparse data" approach when data are not sparse are not without inherent methodological and empirical difficulties, but they are not discussed here.

An Example of the Suggested Approach

The example presented to illustrate the procedure concerns the response of wheat to nitrogen (N) and phosphorus (P) fertilizer at one site in the red-brown earths of the eastern Darling Downs area of Queensland, Australia. Fractional factorial N–P trials were conducted over three seasons 1966–68.[2] A sequence of only three experiments represents an unquestionably sparse set of data, but the spirit of this approach is that, although sparse, these data provide useful information on risk and response.

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[1] Such a subjective method of combining all the relevant information available to the analyst is Bayesian in spirit rather than technique and is analogous to the judgmental procedures analysts use in specifying and selecting among alternative models in conventional statistical practice.

[2] I am grateful to Jim Pulsford and Jim Hitchener of ACF/Austral Fertilizers for making these data available.

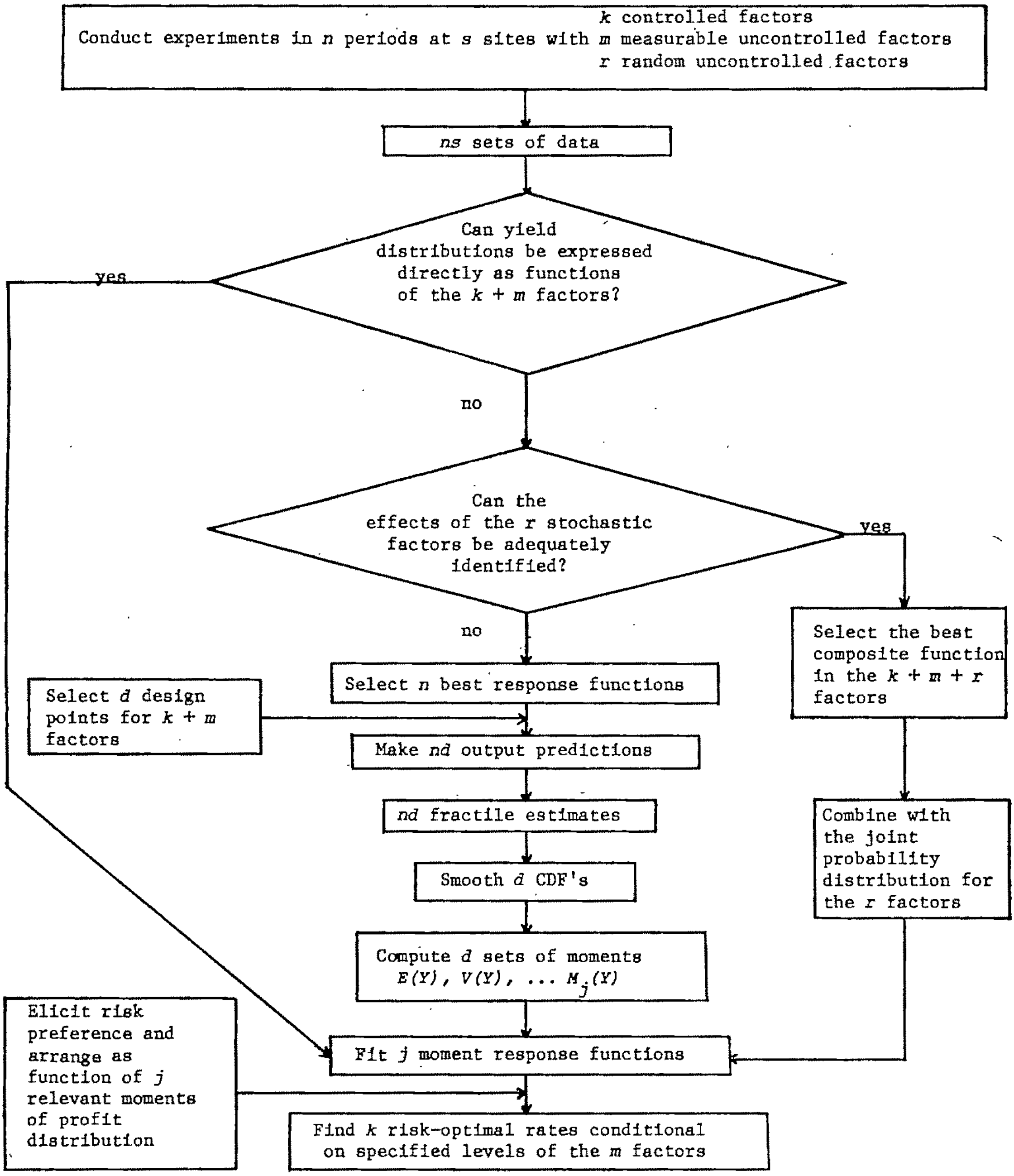
Conduct experiments in n periods at s sites with
k controlled factors
m measurable uncontrolled factors
r random uncontrolled factors
ns sets of data
Can yield distributions be expressed directly as functions of the k + m factors?
yes
no
Can the effects of the r stochastic factors be adequately identified?
yes
no
Select the best composite function in the k + m + r factors
Select n best response functions
Select d design points for k + m factors
Make nd output predictions
nd fractile estimates
Smooth d CDF's
Compute d sets of moments E(Y), V(Y), ... M_j(Y)
Combine with the joint probability distribution for the r factors
Elicit risk preference and arrange as function of j relevant moments of profit distribution
Fit j moment response functions
Find k risk-optimal rates conditional on specified levels of the m factors

Figure 1. A scheme for risky response analysis

Some least-squares manipulation revealed the following first three response functions as adequate *ex post* descriptions of response in each of the seasons; the fourth function was obtained by pooling all the data:

$$(2.1)\quad Y_{66} = \underset{(2.43)}{20.60} + \underset{(0.0927)}{0.3370N} + \underset{(0.2270)}{1.0782P} - \underset{(0.00093)}{0.00301N^2} - \underset{(0.00582)}{0.02342P^2} + \underset{(0.00175)}{0.00461NP},$$

$$\bar{R}^2 = 0.842 \qquad SEE = 4.11$$

(2.2) $$Y_{67} = \underset{(0.97)}{12.52} + \underset{(0.1422)}{0.4328P} - \underset{(0.00389)}{0.00824P^2},$$

$$\bar{R}^2 = 0.410 \qquad SEE = 2.75$$

(2.3) $$Y_{68} = \underset{(0.47)}{19.35} + \underset{(0.0272)}{0.1245N} + \underset{(0.0530)}{0.6667P} - \underset{(0.00033)}{0.00096N^2} - \underset{(0.00149)}{0.01257P^2},$$

$$\bar{R}^2 = 0.899 \qquad SEE = 1.33$$

(2.4) $$Y_{66-68} = \underset{(2.47)}{18.13} + \underset{(0.1079)}{0.1437N} + \underset{(.2377)}{0.7121P} - \underset{(0.00112)}{0.00133N^2} - \underset{(0.00628)}{0.01470P^2} + \underset{(0.00190)}{0.00171NP},$$

$$\bar{R}^2 = 0.211 \qquad SEE = 8.60$$

where Y is wheat yield in bu./ac., N is lb./ac. of nitrogen, and P is lb./ac. of elemental phosphorus, and respective standard errors are reported in parentheses. The data did not permit an adequate specification of the response effects of rainfall, the only stochastic variable recorded in the experiments.

Response functions 2.1–2.3 were used to predict outputs for the 36 points of a 6^2 complete factorial [0(20)100 for N and 0(8)40 for P] which just encompassed the treatments of the three N-P experiments. For each point the three outputs were ranked to give 0.25, 0.50, and 0.75 fractile estimates through which CDF's were hand-smoothed. Even with only three coordinates on each graph, it was found to be quite easy to sketch a sigmoidal curve for which the 0.00 fractile was a non-negative output. The most subjective part of the smoothing was encountered beyond the 0.75 fractile, particularly in determining the 1.00 fractile, but general knowledge of the local environment helped place a ceiling on this maximum conceivable output.

The mean, variance,[3] and third and fourth central moments of the responses were computed from the smoothed CDF's, and these were used as dependent variables in regression functions of the decision variables N and P.[4] Quadratic equations were found to be best for the mean and variance, but statistically acceptable functions were not found for the higher moments. However, reasonable functions were established for the derived measures, relative skewness, $\alpha_3 = M_3/V^{3/2}$, and relative kurtosis, $\alpha_4 = M_4/V^2$. The selected empirical functions corresponding to the equation set (1) were:

(3.1) $$E(Y) = \underset{(0.28)}{17.37} + \underset{(0.0085)}{0.1527N} + \underset{(0.0213)}{0.7068P} - \underset{(0.00008)}{0.00143N^2} - \underset{(0.00047)}{0.01301P^2} + \underset{(0.00016)}{0.00273NP},$$

$$\bar{R}^2 = 0.994 \qquad SEE = 0.453$$

(3.2) $$V(Y) = \underset{(14.78)}{36.18} + \underset{(0.455)}{2.656N} + \underset{(1.137)}{6.553P} - \underset{(0.00404)}{0.02463N^2} - \underset{(0.02524)}{0.19900P^2} + \underset{(0.00864)}{0.08826NP},$$

$$\bar{R}^2 = 0.943 \qquad SEE = 24.20$$

(3.3) $$\alpha_3(Y) = -\underset{(0.097)}{0.577} + \underset{(0.00123)}{0.00378N} + \underset{(0.00308)}{0.02593P},$$

$$\bar{R}^2 = 0.691 \qquad SEE = 0.252$$

(3.4) $$\alpha_4(Y) = \underset{(0.173)}{3.109} - \underset{(0.0061)}{0.0393N} - \underset{(0.0152)}{0.0337P} + \underset{(0.00006)}{0.00034N^2} + \underset{(0.00036)}{0.00133P^2},$$

$$\bar{R}^2 = 0.681 \qquad SEE = 0.349$$

(3.5) $$Med\,(Y) = \underset{(0.13)}{19.14} + \underset{(0.0039)}{0.1309N} + \underset{(0.0098)}{0.6713P} - \underset{(0.00003)}{0.00102N^2} - \underset{(0.00022)}{0.01277P^2},$$

$$\bar{R}^2 = 0.996 \qquad SEE = 0.205.$$

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[3] Note that variance is estimated as a function of the decision variables, implying heteroscedasticity in the *ex post* response functions. However, with the conventionally sized response experiments, nonconstancy of variance of the residuals was not detectable in the individual least-squares regressions.

[4] Moments were calculated approximately from 40 discrete probability elements and corresponding interval midpoints read directly from the CDF's.

Table 1. Illustrative risk-efficient and *ex post* optimal inputs

Procedure for optimization		Optimal rates[a] N lb./ac.	P lb./ac.	Expected profit \$/ac.	Variance of profit $\$^2$/ac.
The risk assessment approach Preference	$[dE(\pi)/dV(\pi)]_u$				
$U=\pi$	0	46	27	21.70	273
$U=$linear function of $E(\pi)$, $V(\pi)$	$(1)10^{-5}$	42	26	21.68	261
$U=\pi-(5)10^{-5}\pi^2$	$(11.1)10^{-5}$	0	28	18.39	70
$U=ln(\pi)$	$(5.68)10^{-5}$	20	25	20.79	180
The conventional *ex post* approach for function:	(2.1)	59	26	21.39	307
	(2.2)	0	18	18.65	99
	(2.3)	15	21	20.33	163
"Average" function	(2.4)	32	21	21.18	226

[a] $Area=300$ ac., $p_y=\$1.05$/bu., $p_n=\$0.10$/lb., $p_p=\$0.14$/lb., $FC=\$6$/ac.

Functions such as these can be used in several ways to aid decision making about use of N and P. For instance, rates that maximize expected profits can be found very simply. The suggestion in Step 6 of using a producer's preference function is quite general and is illustrated here by some alternative assumptions about preference for profits. This approach necessitates aggregation to the farm level and specification of appropriate prices and costs. The realistic assumptions made for purposes of illustration are that $E(\pi)=Area\ [p_yE(Y)-p_nN-p_pP-FC]$ and $V(\pi)=(Area\ p_y)^2V(Y)$ where *Area* is acreage under crop, p_y is net price of a bushel of Y, p_n and p_p are appropriate factor prices, and FC denotes fixed costs per acre. Assuming that preference depends only on mean and variance of profits, i.e., $U=U[E(\pi),\ V(\pi)]$, then the first-order condition for determining the optimal rates (i.e., $\partial U/\partial N=\partial U/\partial P=0$) reduces to $\partial E(\pi)/\partial N-[dE(\pi)/dV(\pi)]_u\partial V(\pi)/\partial N=\partial E(\pi)/\partial P-[dE(\pi)/dV(\pi)]_u\partial V(\pi)/\partial P=0$, where $[dE(\pi)/dV(\pi)]_u$ is the risk evaluation differential quotient [14, p. 27].[5] The risk evaluation quotient depends on the preference function for profits, e.g., for $U=\pi$ it is zero, for $U=\pi+b\pi^2$ it is $-b/(1+2bE(\pi))$, and for $U=\ln(\pi)$, it is $(1/2)E(\pi)/[E(\pi)^2+V(\pi)]$.

Table 1 shows optimal rates for these alternative preferences and compares them with corresponding *ex post* optima and the "average" function optimum, derived from equation set (2), to complete this illustrative example. As might be anticipated by comparing the coefficients for N^2 and P^2 in equation (3.2), nitrogen is a relatively risky input and its optimum is more sensitive to changes in preference. In fact, solution for the quadratic preference function involves a non-negative constraint on N.

Typical of many fertilizer response processes [1], the sensitivity of (expected) profits in this example is not great. However, predicted variances of profit are also reported in Table 1 and reveal considerably greater sensitivity to varying levels of the controlled inputs.

Conclusion

The approach outlined and illustrated is presented in the belief that it is applicable to a range of situations in response analysis where decisions are intrinsically risky and where few data are available.

The procedures suggested for smoothing the assumed sparse data and for measuring response risk are cumbersome compared with conventional techniques of response analysis that ignore risk. However, it may be a small price to pay for relevance when one recalls the irrelevance of most *ex post* analysis of individual experiments in risky decision making.

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[5] This risk evaluation measure is defined as $[dE(\pi)/dV(\pi)]_u=-[\partial U/\partial V(\pi)]/[\partial U/\partial E(\pi)]$, where $\partial U/\partial E(\pi)>0$, and it is the marginal rate of substitution between $E(\pi)$ and $V(\pi)$ while utility is held constant [14].

References

[1] ANDERSON, J. R., "A Note on Some Difficulties in Response Analysis," *Aust. J. Agr. Econ.* 12:46-53, June 1968.

[2] BYERLEE, D. R., AND J. R. ANDERSON, "Value of Predictors of Uncontrolled Factors in Response Functions," *Aust. J. Agr. Econ.* 13:28-37, Dec. 1969.

[3] COLYER, D., "Fertilization Strategy Under Uncertainty," *Canadian J. Agr. Econ.* 17:144–149, Nov. 1969.

[4] DAY, RICHARD H., "Probability Distributions of Field Crop Yields," *J. Farm Econ.* 47:713–741, Aug. 1965.

[5] DE JANVRY, ALAIN, "Optimal Levels of Fertilization Under Risk: The Potential for Corn and Wheat Fertilization Under Alternative Price Policies in Argentina," *Am. J. Agr. Econ.* 54:1–10, Feb. 1972.

[6] DILLON, J. L., "An Expository Review of Bernoullian Decision Theory in Agriculture: Is Utility Futility?" *Rev. Mktg. Agr. Econ.* 39:3–80, March 1971.

[7] DOLL, JOHN P., "Obtaining Preliminary Bayesian Estimates of the Value of a Weather Forecast," *Am. J. Agr. Econ.* 53:651–655, Nov. 1971.

[8] ———, "A Comparison of Annual Versus Average Optima for Fertilizer Experiments," *Am. J. Agr. Econ.* 54:226–233, May 1972.

[9] ———, V. J. RHODES, AND J. G. WEST, *Economics of Agricultural Production, Markets and Policy*, Homewood, Richard D. Irwin, Inc., 1968.

[10] ELDERTON, W. P., AND N. L. JOHNSON, *Systems of Frequency Curves*, Cambridge University Press, 1969.

[11] FULLER, WAYNE A., "Stochastic Fertilizer Production Functions for Continuous Corn," *J. Farm Econ.* 47: 105–119, Feb. 1965.

[12] HALTER, A. N., AND G. W. DEAN, *Decisions under Uncertainty: Applications to Agriculture*, Corvallis, Oregon State University, May 1967, mimeo.

[13] HEADY, E. O., J. T. PESEK, AND W. O. MCCARTHY, *Production Functions and Methods of Specifying Optimum Fertilizer Use Under Various Uncertainty Conditions for Hay*, Iowa Agr. Exp. Sta. Res. Bull. 518, 1963.

[14] MAGNUSSON, G., *Production Under Risk: A Theoretical Study*, Uppsala, Almqvist and Wiksells, 1969.

[15] MOOD, A. M., AND F. A. GRAYBILL, *Introduction to the Theory of Statistics*, New York, McGraw-Hill Book Company, 1963.

[16] SCHLAIFER, R., *Probability and Statistics for Business Decisions*, New York, McGraw-Hill Book Company, 1959.

[17] SMITH, WESLEY G., AND W. L. PARKS, "A Method for Incorporating Probability into Fertilizer Recommendations," *J. Farm Econ.* 49:1511–1515, Dec. 1967.

[18] SWANSON, E. R., AND F. H. TYNER, "Influence of Moisture Regime on Optimum Nitrogen and Plant Population for Corn," *Agronomy J.* 57:361–364, July–Aug. 1965.

Effect of Public Price Forecasts on Market Price Variation: A Stochastic Cobweb Example*

DAVID J. SMYTH

This paper analyzes the effect of less than perfectly accurate forecasting in a stochastic cobweb model when public announcement of the forecasts influences suppliers' behavior. The forecasts considered in the analysis reduce the time variance of price, but the forecasts that minimize the variance are not always the most accurate.

THIS paper undertakes an analysis of the effect of less than perfectly accurate forecasting in a stochastic cobweb model when public announcement of the forecast influences suppliers' behavior. After presenting a deterministic cobweb model and surveying previously published work that has used such a model to analyze the effect of public forecasts, stochastic elements are introduced and the model analyzed on the basis of different forecasting assumptions.

A Deterministic Cobweb Model

The cobweb model is a familiar one in agricultural economics. It supposes a lag in the supply function such as may arise with an annual crop or production of livestock. In the model that is set up it is assumed that in the absence of publicly announced forecasts, supply in time period t is a function of price in time period $t-1$ because this is the latest price the supplier has available on which to base his production decision. More complex assumptions could be made such as suppliers basing their output on a weighted average of past prices [8, 9]. Also ruled out is the possibility of storing the commodity. Demand is taken to be a function of current price.

A simple cobweb model may be written:

$$S_t = a + bP_{t-1} \tag{1}$$

$$D_t = c - P_t \tag{2}$$

where S and D are, respectively, the quantities supplied and demanded; P is the price of the product; t denotes the time period; and a, b, and c are parameters with $b>0$. The demand equation has been written with the coefficient of price equal to -1. This can be done without any loss of generality but with reduction in the complexity of the mathematical expressions derived in the paper because the units in which price and quantity are measured are necessarily arbitrary.[1] The market is cleared by equating the quantities supplied and demanded, hence:

$$S_t = D_t. \tag{3}$$

Substituting from (1) and (2) into (3) and rearranging yields

$$P_t = (c - a) - bP_{t-1}. \tag{4}$$

This is a first-order difference equation and the coefficient of P_{t-1} is negative so price and output will fluctuate about their equilibrium levels giving the familiar cobweb pattern in a supply and demand curve diagram. The equilibrium level of price is obtained by putting $P_t = P_{t-1} = \overline{P}$ and is

$$\overline{P} = (c - a)/b. \tag{5}$$

Fluctuations about the equilibrium position will be convergent, perfectly regular, or divergent, according to whether b is less than, equal to, or greater than unity.

In this model there is no publicly announced prediction of price so each supplier must make his production decision on the basis of his own private forecast. It is assumed each supplier's private prediction is that the price ruling in period t is the same as in period $t-1$.

Literature Review

Many authors have used the cobweb model to analyze public forecasting. Grunberg and Modigliani [4] have shown the following: that provided correct *private* prediction is possible, correct *public* prediction is also conceptually possible; that if public prediction does not

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[1] For instance, price could be measured in dollars or cents and output could be measured in pounds or tons. A change in units will merely lead to proportional changes in the slopes of the supply and demand functions so that their ratio is unchanged.

affect the course of events, correct public prediction coincides with correct private prediction; and that if agents react to the public prediction and their reaction alters the course of events, the reaction can conceptually be known and taken into account.[2]

Devletoglou [3] considered the question—"Is correct public forecasting desirable?"—by analyzing the effect of perfect public forecasting on the stability of the cobweb model. He concluded that it was desirable because accurate public forecasting accelerated the adjustment process in a convergent cobweb, because it might change a divergent cobweb into a convergent one, and because at any point of time the deviation from equilibrium was reduced,[3] even if the cobweb remained divergent.

Rothschild [10] carried the analysis one step further by introducing into Devletoglou's model the more realistic assumption of less than perfect forecasting. He demonstrated that less than perfect forecasting will dampen oscillations but will lead to permanent irregular movements about equilibrium if the forecast is partially accepted; and that a fully accepted forecast will remove large oscillations, but that permanent irregular movements around the equilibrium position will occur.

All these studies were in terms of a deterministic cobweb model without stochastic terms in the demand and supply functions. The present paper extends the analysis further by allowing for stochastic elements.[4]

Introduction of Stochastic Elements without Public Forecasts

Introducing stochastic terms into the supply and demand functions, the cobweb model becomes:

$$S_t = a + bP_{t-1} + u_t \tag{6}$$

$$D_t = c - P_t + v_t \tag{7}$$

$$S_t = D_t. \tag{8}$$

Substituting from (6) and (7) into (8) and rearranging yields

$$P_t = (c - a) - bP_{t-1} + v_t - u_t. \tag{9}$$

The stochastic terms in equations (6) and (7) represent causal factors not specified in the model, such as variations in the weather which influence output in the case of an agricultural supply function and variations in tastes which influence the demand function. It is assumed that the disturbance terms u_t and v_t are non-autocorrelated random variables with mean zero and respective variances σ_u^2 and σ_v^2. Then, variance of the composite disturbance term in equation (9), $v_t - u_t$, is $(\sigma_u^2 + \sigma_v^2 - 2r_{uv}\sigma_u\sigma_v)$, where r_{uv} is the correlation between u_t and v_t. If u_t and v_t are uncorrelated, the variance of the composite disturbance is simply $\sigma_u^2 + \sigma_v^2$. The composite disturbance term is denoted by w_t so that

$$w_t = v_t - u_t \tag{10}$$

and its variance is written as σ_w^2. Substituting from (10) in (9) gives the equation for price as:

$$P_t = (c - a) - bP_{t-1} + w_t. \tag{11}$$

Equation (11) is a linear first-order stochastic difference equation. Fluctuations in price take place about the equilibrium price $\bar{P}$. This equilibrium price is obtained by putting $P_t = P_{t-1} = \bar{P}$ and $w_t = 0$, and so is given by

$$\bar{P} = (c - a)/b. \tag{12}$$

A convenient measure of the magnitude of the fluctuations in a variable is its variance. In equation (11) the asymptotic variance of price is

$$\mathrm{Var}\,(P) = \sigma_w^2/(1 - b^2), \tag{13}$$

provided the cobweb is convergent ($b < 1$); if the cobweb is divergent the variance is infinite.[5]

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[1] They show that the boundedness of the variables of the predictive system and the continuity over the relevant intervals of the functions relating the variables to each other are sufficient but not necessary conditions for the existence of correct public predictions, and that these conditions are normally to be fulfilled in the world about which predictive statements are to be made.

[3] Note that Devletoglou associated "desirability" with reduced fluctuations. This ignores some other aspects of the question. For instance, reduction in fluctuations may reduce the average incomes of producers, which may be regarded as "undesirable." In the present paper we shall concentrate on the positive question of whether public forecasting reduces fluctuations without making any normative judgments.

[4] The present paper is concerned with cobweb models. Kemp [6, 7], Grunberg and Modigliani [4], and Chiang [2] have considered the question of self-validation of forecasts when the subject of forecasts is influenced by the forecasts themselves in a simple macro model. Again, the model they use is a deterministic one. In a forthcoming paper I shall examine the effect of less than perfectly accurate forecasting within the context of a stochastic macro model.

[5] The variance of X in a linear first-order stochastic difference equation

Stochastic Elements with Public Forecasts

A forecaster is now introduced, and it is assumed that he makes an econometric estimate of the system given by equations (6) to (8). If the system is actually as given by (6) to (8), and if this system is properly estimated, unbiased estimates of the parameters may be obtained. In general, it is not expected that the forecaster would be able to forecast the disturbance terms in the supply and demand functions so that he will be unable to forecast the composite disturbance w_t. The best estimate that he can make of w_t is to assume that it is zero. Using (9), his forecast of price P_t^* is then given by:

$$P_t^* = (c - a) - bP_{t-1}. \tag{14}$$

If this forecast price is not announced, it cannot influence suppliers' behavior, and the variance of price is as before.

Now suppose that the forecast is made public and that proportion g of suppliers believe the forecast and use it to determine their supply for period t where $0 \leq g \leq 1$.[6] What effect will announcement of the price forecast have upon the magnitude of fluctuations in price measured by the time variance of price? Note that in this section it is assumed that the forecaster does not modify his forecast to take account of the proportion of suppliers acting upon the forecast; this possibility is considered in the next section.

The supply function now becomes[7]

$$S_t = a + bgP_t^* + b(1 - g)P_{t-1} + u_t. \tag{15}$$

Substituting for P_t^* from (14) yields the new supply function

$$\begin{aligned} S_t = {} & a(1 - bg) + bg(c - a) \\ & + b(1 - g - bg)P_{t-1} + u_t. \end{aligned} \tag{16}$$

As g is increased from 0, the coefficient of P_{t-1} falls until it is zero at $g = 1/(1+b)$ and then becomes negative. When $g = 1$ the coefficient of P_{t-1} is b^2. If price is measured on the vertical axis of a diagram and quantity on the horizontal axis, then as g increases the supply curve becomes steeper and steeper; at $g = 1/(1+b)$ it becomes vertical, and for values of g above $1/(1+b)$ it becomes downward sloping.

Substituting for S_t from (16) and for D_t from (7) into the market-clearing equation (8), and then substituting for w_t from (10) yields the following equation for the determination of price:

$$\begin{aligned} P_t = {} & (1 - bg)(c - a) \\ & - b(1 - g - bg)P_{t-1} + w_t. \end{aligned} \tag{17}$$

The parameter g can take values between 0 and 1, and as g increases from 0 to 1, the coefficient of P_{t-1} in (17) increases monotonically. However, as g is increased, the absolute value of the coefficient of P_{t-1} falls from b, when $g = 0$; to 0, when $g = 1/(1+b)$; and then rises to b^2, when $g = 1$. The disturbance term in (17) is the same as in (11). Thus, comparing (17) with (11), if the initial cobweb in (11) is stable, i.e., $b < 1$, the variance of price is always reduced by the announcement of the forecast. The variance of price in (17) is

$$\text{Var}(P) = \frac{\sigma_w^2}{1 - b^2(1 - g - bg)^2}. \tag{18}$$

The extent to which announcement of the forecasts results in reduction in the variance of price depends, for given b, on the size of g. As

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$$X_t = \alpha + \beta X_{t-1} + \delta_t, \tag{i}$$

where α and β are constants and δ is a nonautocorrelated random variable with mean zero and variance λ^2, is

$$\text{Var}(X) = \lambda^2 \sum_{i=0}^{t} \beta^{2i} = \lambda^2 \left[\frac{1 - \beta^{2(t+1)}}{1 - \beta^2}\right] \tag{ii}$$

and

$$\lim_{t\to\infty} \text{Var}(X) = \frac{\lambda^2}{1 - \beta^2} \tag{iii}$$

where $|\beta| < 1$ [1, p. 156ff]. Equation (iii) gives the asymptotic variance and it is this that will be used throughout this paper; for convenience the adjective "asymptotic" will not be used each time "variance" appears. If $|\beta| > 1$, the variance of X is infinite, as the magnitude of fluctuations in X increases without limit in the case of $\beta < -1$ and X grows or declines without limit if $\beta > 1$. Given the variance of the disturbance term, the variance of X is decreased or increased according as $|\beta|$ is decreased or increased (for $|\beta| < 1$).

[6] g could also be interpreted as including suppliers who use (13) privately.

Since demand depends on current price, announcement of the forecast has no effect on the demand schedule.

[7] By weighting P_t^* and P_{t-1} in the ratio g to $1 - g$ and leaving the supply response coefficient, b, unchanged, the equilibrium response of supply to price is left unchanged as

$$S_t = a + b\bar{P}. \tag{i}$$

There is no reason to suppose that substitution of the publicly forecasted price for the suppliers' own forecast price will alter the magnitude of the supply response to price. Similarly, there seems to be no reason why the disturbance term should be changed.

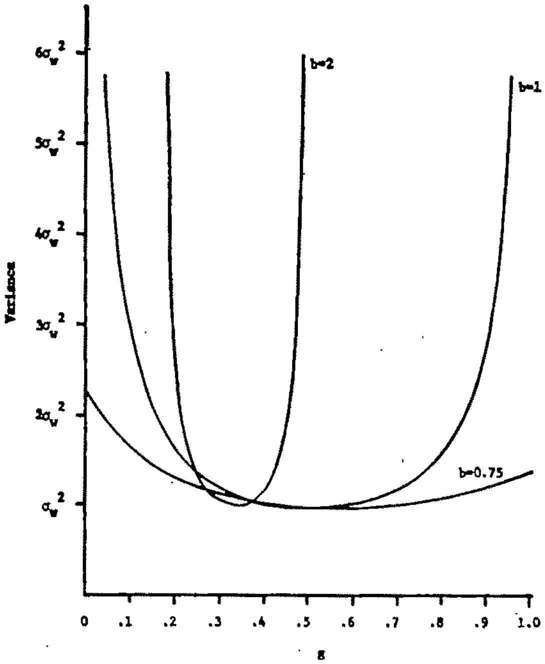

Figure 1. **Variance of price: forecaster ignoring suppliers reactions to forecasts**

g increases from 0 to $1/(1+b)$ the variance of price falls, and when $g=1/(1+b)$ the variance of price is σ_w^2, which is the variance of w_t. This is the minimum variance of price that may be obtained given that w_t cannot be forecast. It corresponds to a vertical supply curve (the coefficient of P_{t-1} equal to zero in (16) so that changes in price induce no changes in output). As g increases to 1, the variance of price increases to $\sigma_w^2/(1-b^4)$ which is still less than that for $g=0$, as b^4 is less than b. Note that for values of g greater than $1/(1+b)$ the coefficient of P_{t-1} is positive. This means there is no longer a cobweb model; if w_t were to be held constant, then price would approach an equilibrium asymptotically. This results from the supply curve, equation (16), being downward sloping in this range.

If the cobweb without announcement of the forecast is divergent, i.e., $b>1$, then there are some values of g for which the system becomes stable. The absolute value of the coefficient of P_{t-1} in (17) is less than 1 for $(b-1)b(1+b) < g < 1/b$, so that the variance is finite. As before, the variance of price assumes its minimum value, σ_w^2, when $g=1/(1+b)$. Also as before, there is no cobweb for values of g greater than $1/(1+b)$; if w_t were to be held constant, price would move asymptotically towards an equilibrium for $1/(1+b)<g<1/b$ and move continuously away from its equilibrium value for $1/b<g<1$.

The extent to which public announcement of the forecast reduces variance of price depends on the size of b and g. Figure 1 illustrates how announcement of the forecast may reduce variance of price and how variance changes for different values of g. Note that the value of g which minimizes the variance of price, $g=1/(1+b)$, falls as b rises. Minimum variance of price occurs with g greater than or less than 0.5, according to whether b is less than or greater than 1. Thus, a highly unstable cobweb may be stabilized by announcement of the forecast if the proportion of suppliers acting on the forecast is small.[8]

Modification of Forecast to Account for Suppliers' Response

So far it has been assumed that the forecaster does not take into account the possible effect upon suppliers of the announcement of his forecast. It is now assumed that the forecaster knows the value of g and takes it into account in making his forecast. This may perhaps be viewed as the second stage in the making of forecasts. In the first stage (described in the previous section) the forecaster had no data on which to base his estimate of g. Now, enough time has elapsed for data to be accumulated so that he may estimate g.

Making use of (7), (8), and (15) and putting the disturbance terms equal to zero, the forecaster's prediction will be

$$(19) \quad P_t^* = (c-a) - bgP_t^* - b(1-g)P_{t-1}.$$

Rearranging will give:

$$(20) \quad P_t^* = \frac{c-a}{1+bg} - \frac{b(1-g)}{1+bg} P_{t-1}.$$

Substituting for P_t^* in (15) gives for the supply curve

$$(21) \quad S_t = \frac{a+bcg}{1+bg} + \frac{b(1-g)}{1+bg} P_{t-1} + u_t,$$

and combining (21) with (7) and (8) yields the following expression for price:

$$(22) \quad P_t = \frac{c-a}{1+bg} - \frac{b(1-g)}{1+bg} P_{t-1} + w_t.$$

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[8] The above analysis has dealt solely with the variance of price. But exactly the same conclusions may be reached concerning quantities.

If $g = 0$ the same result is obtained as without forecasting, as in (9). As g is increased from 0 to 1, the absolute value of the coefficient of P_{t-1} declines monotonically to take the value 0 for $g = 1$. Note that the sign of the coefficient of P_{t-1} is negative for all values of g between 0 and 1 so there is a cobweb process throughout; this is so because the coefficient of P_{t-1} in the supply curve (21) is positive for $0 < g < 1$. The variance of price is finite if the abolute value of the coefficient is less than 1, i.e,. if $g > (b-1)2b$, in which case the variance is given by

$$\text{(23)} \qquad \text{Var}\,(P) = \frac{\sigma_w^2}{1 - \dfrac{b^2(1-g)^2}{(1+g)^2}}\,.$$

The variance of price declines monotonically as g increases. Figure 2 illustrates how variance of price is reduced as g is increased for different values of b.[9]

When the forecaster takes into account the reaction of suppliers to his forecast, he is making the most accurate forecasts of price as are possible if he cannot forecast the disturbance term for [using (20) and (22)]:

$$\text{(24)} \qquad P_t - P_t^* = w_t.$$

However, it does not follow that forecasting as accurately as possible necessarily minimizes the variance of price for given g. This is easily proved. For any given value of b the variance of price yielded by forecasting as accurately as possible, i.e., using (20), is greater than σ_w^2 for all g less than 1. But for forecasts using (14), there is some value of g less than 1 that reduces variance of price to σ_w^2. Figure 3 reproduces the curves for $b = 2$ from Figures 1 and 2. It illustrates that for some values of g the variance of price is greater if the forecasts are made from the more accurate (20) than if they are made from (14) which ignores suppliers' reactions.

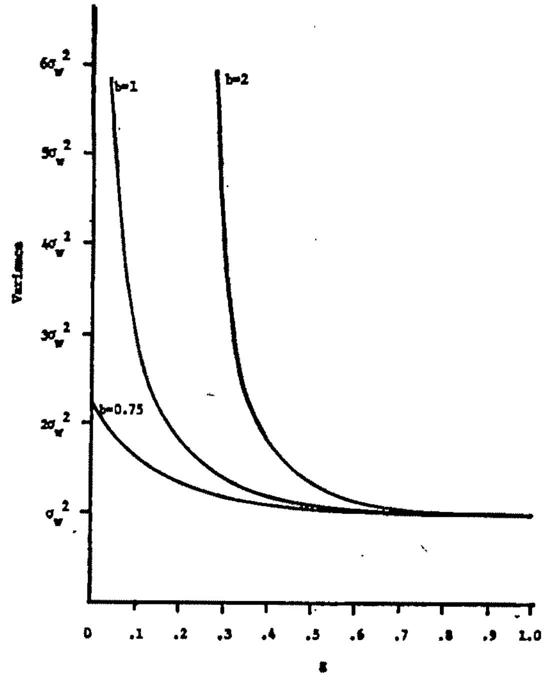

Figure 2. Variance of price: forecaster incorporating suppliers' reactions to forecasts

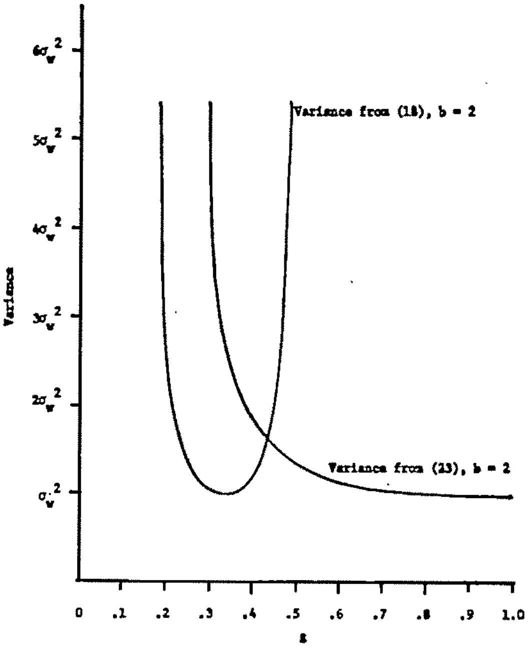

Figure 3. Variance of price: alternative forecasting procedures

Conclusions

This paper has analyzed the effect of public announcement of forecasts in a stochastic cobweb model. It was assumed that the forecaster knew the demand and supply parameters but was unable to forecast the stochastic term. It was assumed first that the forecaster ignored suppliers' reactions to announcement of his forecasts and second that these were taken into account. In both cases it was found (1) that if the variance of price was finite without announcement of the forecasts, then the variance was reduced by public announcement of the forecasts; and (2) that if the variance without the forecasts was infinite, announcement of the forecasts might make the variance finite. Hence, it may be concluded that in the model investigated public announcement of the forecasts tends to stabilize prices. The extent to which announcement of the forecasts reduced the variance of price and, hence, had a stabilizing effect depends on the proportion of suppliers believing the forecast. Since minimum variance of price was obtained with less than all suppliers believing the forecast when the forecaster did not take suppliers' reactions into account, and with all suppliers believing the forecast when the reactions are taken into account with the forecast, the variance of price can be lower if the forecaster does not take suppliers' reactions into account than if he does.

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[9] It can also be shown that the variance of quantity behaves similarly to that of price.

These conclusions have been reached using a particular and fairly simple dynamic model. They may not hold in more complex models. There are various ways in which the model used in this paper could be made more elaborate. For example, supply and demand relationships could be assumed to shift in nonrandom manner over time; a more complicated cobweb model and alternative assumptions about expectations (such as those to be found in [8, 9]) could be used; and the possibility of storage could be incorporated into the model. The author is currently investigating these possibilities. They add considerably to the mathematical complexity of the analysis.

References

[1] BARTLETT, M. S., *An Introduction to Stochastic Processes*, London, Cambridge University Press, 1966.

[2] CHIANG, ALPHA C., "Economic Forecasting When the Subject of the Forecast Is Influenced by the Forecast: Comment," *Am. Econ. Rev.* 53:730–734, Sept. 1963.

[3] DEVLETOGLOU, EVANGELOS A., "Correct Public Prediction and the Stability of Equilibrium," *J. Polit. Econ.* 69:142–161, April 1961.

[4] GRUNBERG, EMILE, AND FRANCO MODIGLIANI, "The Predictability of Social Events," *J. Polit. Econ.* 62: 465–478, Dec. 1954.

[5] ———, "Economic Forecasting When the Subject of the Forecast Is Influenced by the Forecast: Comment," *Am. Econ. Rev.* 52:734-737, Sept. 1963.

[6] KEMP, MURRAY C., "Economic Forecasting When the Subject of the Forecast Is Influenced by the Forecast," *Am. Econ. Rev.* 52:492–496, June 1962.

[7] ———, "Economic Forecasting When the Subject of the Forecast Is Influenced by the Forecast: Reply," *Am. Econ. Rev.* 53:738–740, Sept. 1963.

[8] MUTH, JOHN F., "Rational Expectations and the Theory of Price Movements," *Econometrica* 29:315–335, July 1961.

[9] NERLOVE, MARC, "Adaptive Expectations and Cobweb Phenomena," *Quart. J. Econ.* 72:227–240, May 1958.

[10] ROTHSCHILD, K. W., "Cobweb Cycles and Partially Correct Forecasting," *J. Polit. Econ.* 71:300–305, June 1964.

On Some Determinants of Farm Size Across Countries*

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Several measures of average farm size are developed, using resource endowment, degree of industrialization, factor proportions as the explanatory variables for 53 countries. The three determinants explain much of the variation in average farm size, using cross-sectional regression techniques.

AVERAGE farm size varies tremendously across countries. Is this variation a purely random phenomenon, primarily determined by noneconomic variables such as laws of inheritance, historical consequences of landlord-tenant relationships, or government policies restricting or increasing farm size; or are there certain quantifiable economic determinants operating across all countries? To the author's knowledge, this question has never been empirically examined.

To define what is meant by farm size is difficult, and to quantify or classify all possible determinants would seem a monumental task. The method here is to develop several measures of average farm size and three determining variables for a sample of 53 countries. The basic hypothesis is that farm size patterns have evolved under the influence of political, social, and economic conditions which vary greatly among countries. Social and political factors are less easily generalized and quantifiable, but the three economic factors selected may prove to be of sufficient importance to merit their study in isolation.

It is generally realized that policies affecting size of farms have important normative and positive economic consequences [1, 2, 9]. In the developing nations farm size is related to questions of land reform and desires to redistribute wealth with hopes that productivity will not be damaged. In the developed nations where large farms are rapidly dominating agriculture, the question is one of efficiency in production versus society's view that modest-sized "family farms" are desirable for social and political reasons. Given the considerable controversy as to whether farms should be large or small, it would be interesting to see if differences in size across countries can be explained in terms of differences in economic conditions.

Concepts and Data

This study focuses on three variables whose effects on farm size can be presented in a very simple framework. Since many of these ideas have been adequately developed elsewhere [1, 2, 7, 9, 10], a more rigorous discussion would appear unnecessary.

Resource endowment

Imagine a country in the very early stages of development with the overwhelming majority of the population economically dependent on the land. There are negligible employment opportunities in the nonagricultural sector. Aside from the effects of particular social and political factors, the average size of farms is primarily determined by the population land ratio, calculated as the ratio of the total population in 1960 to the total agricultural land in hectares, using data from [4, 13]. The force at work involves competition among the population for the scarce resource or agricultural land. The greater the population land ratio, the poorer the resource endowment and the smaller the average farm size.

Industrialization

As job opportunities are created in the nonagricultural sector, migration out of agriculture will occur. This migration will release land to be used by the remaining farmers, thus increasing farm size. As a measure of the extent of nonagricultural employment opportunities, the percentage of GNP which originates from the nonagricultural sector in 1960 [14] is used and will be referred to as the GNP industrialization ratio. An alternative measure will be the percentage of the male labor force in nonagricultural activities in 1960 or the labor industrialization ratio [11]. Less weight is placed on this measure because of data limitations, although conceptually it may be more accurate. In

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several cases labor censuses were unavailable for the appropriate year and interpolation or extrapolation was needed. In addition, labor force data differ somewhat in concept and coverage among countries.

Factor proportions

As development proceeds, there is a change in relative factor proportions in agriculture due to changes in relative factor prices as the cost of capital relative to labor falls and to changes in the nature of the production function which make use of capital more profitable [7, pp. 567–570; 6, Ch. 6]. Greater use of capital inputs increases fixed costs in farming and increases optimal farm size as determined by the minimum point on the average cost curves. Assuming profit-maximizing behavior, farms should gravitate toward the optimal size. As a measure of differences in relative factor proportions, ratio of tractor horsepower to the male agricultural labor force in 1960 is used. This variable will henceforth be referred to as the tractor labor ratio. Labor data came from [11] and tractor horsepower data from [6, Appendix A] and from the author's calculations based on [5]. The method was to aggregate farm tractors and garden tractors by assigning weights of 30 and 5 horsepower, respectively, the same method used in [6].

Choosing a measure of farm size is somewhat arbitrary even assuming that all appropriate information is available. Area cultivated, output, or input levels may all be used depending upon one's purposes; moreover, it is difficult to define conceptually a farm "unit" in terms of ownership or functions.[1] The choice is necessitated by the available data and concepts in the 1960 FAO Census of Agriculture,[2] which classifies agricultural land into five categories: arable land or land under temporary crops (growing cycle less than one year) or temporarily fallow; land under permanent crops (generally trees or shrubs); permanent meadows and pastures; wooded land; and other land. The five categories are defined as the total agricultural land.

In deriving a measure of farm size, the Census' concept of an agricultural holding is used. A holding is all land used wholly or partly for agricultural production and operated by one person, alone or with the assistance of others without regard to title, size, or location. Dividing the total agricultural land area (in hectares) by the total number of agricultural holdings gives the average *agricultural farm size.* This variable probably comes closest to the normal concept of farm size generally referred to in the literature. It has the disadvantage in aggregating over a wide variety of crops and environmental and technical conditions, and making no distinctions as to whether the land is cultivated or fallow, wooded or pasture. To alleviate some of these problems, several other definitions of farm size were developed. The Census reported in each case the number of holdings growing a specific temporary crop on arable land and the area cultivated. For each country the total area for the five most important crops was divided by the total number of holdings growing these crops to yield the average *arable farm size.* It has the advantage in including only cultivated arable land and being restricted to the most important crops. It is not, however, a good measure of farm size in the normal sense since a typical farm may grow several crops and also leave much of the land fallow.

Since environmental and technological requirements, which vary according to the type of crop, may influence farm size, some standardization is possible by deriving two other measures. The two most frequently grown crops in the sample are wheat and rice. The total area under each crop is divided by the number of holdings growing each crop to derive an average *wheat farm size* and an average *rice farm size.* In addition, two measures of farm size based on livestock are calculated. The total heads of cattle are divided by the number of holdings owning cattle to give a meaure of average *cattle farm size.* The same method yields an average *chicken farm size.*

Since any particular concept of farm size is arbitrarily determined, a criterion used here as to whether the three variables can explain a significant proportion of the variation in farm size is whether they have significant explanatory power for all six of the above measures. If so, it is concluded that the variables are important in determining average farm size, regardless of the particular concept chosen to measure it.

Sample size in this study ranges from 53 countries to 29, depending upon the dependent variable, and covers most of the regions in the world with the exception of sub-Saharan African countries where the nature of land tenure systems makes the concept of the farm size irrelevant.

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[1] A farm may be one man farming one hectare, a large corporation, a village with collective ownership, or a state farm. The land may be rented, owned, partially owned, or unclaimed.

[2] The concepts are presented in [4, Vol. II]. Most of the censuses were taken during 1958–63. Data for four countries were taken from provisional reports presented in [3].

Empirical Findings and Implications

Since there is no *a priori* basis for predicting the exact form of the regressions, plots of the data and a study of the correlation coefficients were used. These efforts indicated a nonlinear relationship. The best fit appeared to be a semilog equation of the form:

$$\text{Log } Y = a + bR + cI + dF$$

where Y is one of the six measures of farm size and the three explanatory variables are those measuring resource endowment, industrialization, and factor proportions. For consistency, this form is used for each of the six measures of farm size. Two regressions are run for each measure, the difference being the use of either the GNP industrialization ratio or the labor industralization ratio as indicators of the extent of nonagricultural employment opportunities. The results are presented in Table 1.

For the four crop measures for farm size, statistical significance and explanatory power of the three independent variables are consistently good.[3] These three variables are able to explain more than 50 percent of the variance in each case—a rather surprising result, given that this is a cross-sectional analysis of a very complex phenomenon.[4] The results are understandably slightly poorer for the livestock measures. For cattle farm size, the factor proportions variable may be less significant because of differences in the type of production function for that industry versus crop production.[5] For the chicken

Table 1. Empirical results

Dependent Variable	Log Average Agricultural Farm Size		Log Average Arable Farm Size		Log Average Wheat Farm Size		Log Average Rice Farm Size		Log Average Cattle Farm Size		Log Average Chicken Farm Size	
Intercept	0.612 (0.60)[a]	1.976 (4.00)	0.183 (0.19)	0.417 (0.86)	−0.288 (−0.19)	−0.224 (−0.28)	−0.379 (−0.30)	−0.260 (−0.46)	0.673 (0.56)	1.395 (2.43)	1.174 (1.05)	1.909 (3.48)
Population Land Ratio	−0.281 (−6.66)	−0.304 (−6.88)	−0.149 (−3.20)	−0.154 (−3.30)	−0.208 (−3.33)	−0.216 (−3.55)	−0.146 (−2.55)	−0.166 (−3.16)	−0.168 (−3.63)	−0.191 (−4.09)	−0.020 (−0.46)	−0.039 (−0.87)
GNP Industrialization Ratio	3.261 (2.41)		0.678 (0.55)		1.639 (0.85)		1.917 (1.10)		2.592 (1.61)		2.367 (1.53)	
Labor Industrialization Ratio		2.203 (2.31)		0.537 (0.62)		2.134 (1.62)		2.758 (2.42)		2.374 (2.26)		1.987 (1.90)
Tractor Labor Ratio	0.053 (2.28)	0.038 (1.36)	0.070 (3.38)	0.066 (2.80)	0.075 (2.72)	0.054 (1.78)	0.086 (3.00)	0.058 (1.99)	0.034 (1.26)	0.015 (0.53)	0.065 (2.46)	0.054 (1.94)
R^2	.62	.62	.51	.51	.56	.59	.54	.61	.45	.48	.46	.48
Sample Size	53	53	42	42	31	31	30	30	36	36	29	29

[a] Figures in parentheses are *t*-values.

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[3] The semilog specification was generally the best in all cases except for the average agricultural farm size where a log-log specification increased the R^2 to above .90 and the *t*-values for all three independent variables were higher.

[4] As an alternative to the population land ratio as a measure of resource endowments, some regressions were run using the male agricultural labor force to land ratio. This variable generally yields poorer results due to multicollinearity because the labor-land ratio is highly correlated with the industrialization variable while the population-land ratio is not. This is somewhat predictable since the labor-land ratio is influenced by the extent of industrialization which affects the labor force in agriculture. The labor-land ratio thus captures part of the effects of both the resource endowment variable (the population-land ratio) and the industrialization variable.

[5] Capital inputs may be less important in cattle farming but still important in poultry raising. Tractor inputs are

farm size, the resource endowment variable may be insignificant since land is not an important constraint in that industry.

Since the empirical results are consistent for each of the four crop measures and compatible with the implications of the livestock measures, it is concluded that the three economic factors explain a large portion of the variance in farm size if measured in terms of crop area. Within a "stage of development" framework, one can view farm size as being initially determined by a country's resource endowment, which over time may change with population growth and clearing of land. With development, increases in nonagricultural employment opportunities and changes in technology and factor proportions will cause pressures for farm size to increase.

An implication of the findings of this study is that there is no one optimal size for all countries. Moreover, the optimal size for any one country will be constantly changing in response to dynamic conditions. As for the near future, it is predicted that in many LDC's average farm size will not change significantly. Industrialization has encouraged heavy rural-urban migration, but the rate of job creation has been disappointing and migration may be less severe in the future. Changing factor proportions are not likely to be significant in LDC's since capital is not likely to get cheaper, relative to labor, for many years. The increasing population, however, coupled with land scarcity will alter resource endowment so as to reduce farm size. The net effect of all three factors will probably be small. In the more developed countries, changing factor proportions and continued rural-urban migration, coupled with minor population pressures, will continue to increase farm size even in the presence of neutral government policy.[6]

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obviously not the proper conceptual measure of the use of capital in the poultry industry but may be closely correlated to the actual capital used in that industry.

[6] Further research on the determinants of farm size patterns would appear to be very interesting. For example, why do land tenure patterns differ so much across countries and does this affect farm size? Why is the distribution of farms according to size so different across countries and will it be affected by development? This study has focused on the mean, but analysis of the extremes is an equally important issue.

References

[1] BACHMAN, K. L., AND R. P. CHRISTENSEN, "The Economics of Farm Size," in *Agricultural Development and Economic Growth*, eds., Herman M. Southworth and Bruce F. Johnston, Ithaca, Cornell University Press, 1967, pp. 234–257.

[2] BALL, A. GORDON, AND EARL O. HEADY, eds., *Size, Structure, and Future of Farms*, Ames, Iowa State University Press, 1972.

[3] FAO, *Monthly Bulletin of Agricultural Statistics*, Rome, various issues.

[4] ———, *Report on the 1960 World Census of Agriculture*, Rome, 1966–1970.

[5] ———, *Statistical Yearbook*, Rome, various issues.

[6] HAYAMI, YUJIRO, AND VERNON W. RUTTAN, *Agricultural Development: An International Perspective*, Baltimore, The Johns Hopkins Press, 1971.

[7] HEADY, EARL O., *Agricultural Policy Under Economic Development*, Ames, Iowa State University Press, 1962.

[8] ———, "Optimal Sizes of Farms Under Varying Tenure Forms, Including Renting, Ownership, State, and Collective Structures," *Am. J. Agr. Econ.* 53:17–25, Feb. 1971.

[9] ———, AND A. GORDON BALL, "Public Policy Means and Alternatives," in *Size, Structure, and Future of Farms*, eds., A. Gordon Ball and Earl O. Heady, Ames, Iowa State University Press, 1972.

[10] HELMBERGER, PETER G., "Markets, Farm Size, and Integration," in *Size, Structure, and Future of Farms*, eds., A. Gordon Ball and Earl O. Heady, Ames, Iowa State University Press, 1972.

[11] ILO, *Yearbook of Labor Statistics*, Rome, various issues.

[12] MELLOR, JOHN W., *The Economics of Agricultural Development*, Ithaca, Cornell University Press, 1966.

[13] United Nations, *Demographic Yearbook*, New York, 1964.

[14] ———, *Yearbook of National Accounts Statistics*, New York, various issues.

An Evaluation of Short-Term Forecasts of Coffee and Cocoa

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Predictive performance of short-term forecasts of production is evaluated using a technique which minimizes the average squared difference between actual and forecast values. Forecasting errors are decomposed into two components reflecting the forecast system and a residual component. Many forecasts resulted in underestimation and contained large but unsystematic errors.

EXPORTS of coffee and cocoa are an important source of foreign exchange to many Latin American and African nations. These tree crops are also of vital importance to the economic well-being of numerous peasant smallholders. Accordingly, there has been great concern with the export-earning prospects of various producing nations. Agencies and organizations such as the United States Foreign Agriculture Service (FAS) and the United Nations Food and Agricultural Organization (FAO) publish short-term forecasts of production in the growing regions [1, 3, 11, 12]. Presumably these forecasts contribute to the policy decisions of private importers, marketing boards, and producing nations' governments. Up to the present, however, few systematic evaluations of these forecasts have been conducted. Their predictive performance is therefore comparatively unknown.

Available Forecasts

For coffee, it appears that the most easily available and probably the most widely circulated annual forecasts are those made by the FAS [12]. These official U. S. Government estimates are used often in the coffee trade and probably have considerable influence among groups that may not have access to some of the sources consulted by the FAS in preparing its estimates. In addition, the International Coffee Organization (ICO) makes short-run forecasts that are not publicly available, and George G. Paton and Co. of New York has published short-run forecasts since the mid-1960's.

The FAS prepares four annual estimates of total production and exportable production (estimated total production minus estimated consumption in producing countries) for the coming coffee year, which extends officially from October 1 to September 30. Harvesting and exporting seasons, however, vary widely from country to country. The first estimate, labeled E1 by the FAS, is made the preceding June, the second, E2, in September, the third, E3, in December, and the fourth, E4, in March—six months into the coffee marketing year.[1]

Estimates are prepared on the basis of information supplied by official government statistics of the producing nations, national coffee agencies and marketing groups, as well as field reports from U. S. agricultural attachés and Foreign Service officers who conduct surveys in the producing areas with private producers, exporters, and other informal contacts. Each new estimate entails corrections of the initial figures as more accurate reports come from the field, marketing of the new crop proceeds, and new developments arise. The fourth estimate is not considered final since revisions continue for months afterward until a final published figure is determined. These figures are the main source of most of the production data used by the Pan-American Coffee Bureau in its publications [9]. FAS does not appear to generate or use these estimates with any specific purpose other than to disseminate information to those interested in current development of coffee production.

For cocoa, the published forecasts referred to were those of (1) the FAS [11, 14]; (2) the Cocoa Study Group, Statistics Subcommittee, of the FAO [3]; and (3) Gill and Duffus, Ltd., of London [5].[2]

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[1] The estimates are published in [12] each July, October, January, and April.

[2] The FAS forecasts are published regularly in [14], with projections in the February, October, and December issues

Each of these agencies uses a similar survey technique of forecasting, and evidently some overlap exists in their sources of information. Each relies on sources of information within the producing country: government officials, agents of large commercial users of cocoa, and semi-official interested groups (e.g., marketing boards). In addition, FAS uses the reports of U. S. foreign agricultural attachés for producing regions, who in turn probably rely on the types of sources mentioned earlier. Factors such as extent of spraying against pests, weather, producer prices, disease control, etc., and their effects on production prospects are incorporated in the forecasts in a judgmental manner.

Contrasting to the foregoing rather informal forecasting techniques is the cocoa production forecast prepared and submitted to the FAO by the Ministry of Agriculture, Rural Statistical Service, of the Ivory Coast. In a procedure apparently unique to the Ivory Coast, forecasts are based on a sample of approximately 400 standardized producing units throughout the country and utilize a simple pod count (with pods divided into two size classes) as a basis for production estimates in the sample units. These estimates are inflated to achieve a national production forecast [2, 4].

No regular review of these various forecasts is undertaken to determine their degree of reliability. Moreover, little communication seems to exist between forecasting agencies and users of the forecasts.

Forecast Evaluation

Ideally, the criterion of forecasting performance can be defined in terms of the loss function of the user of the forecasts. Moreover, from a technical standpoint, it would be desirable to detail the sources of the deviations from realized values as can be done with long-run projections which employ structural models. However, these alternatives are not available for the informal forecasting procedures being reviewed here. The method selected for determining absolute accuracy was devised by Mincer and Zarnowitz [8]. This method can be used to analyze forecasts not formulated by means of an explicitly stated model that can be reproduced to test its predictive power.

Essentially, the Mincer-Zarnowitz technique takes as the goal of forecasting the minimization of the mean-square-error (*MSE*), that is, the average squared difference between the actual and forecast values. The sample *MSE* is defined as:

$$MSE = \sum_{t=1}^{n} \frac{(A_t - E_t)^2}{N},$$

where A_t are actual values; E_t, forecast values; and N, the number of observations. This is a measure of dispersion around the line of perfect forecast (*LPF*), which can be conceived as a 45° line through the origin, and it is used to analyze absolute forecast accuracy. A least squares straight line must be fitted to a scatter diagram of actual realization (A_t) and estimates (E_t):

$$A_t = \alpha + \beta E_t.$$

Ideally, the entire regression line should coincide with *LPF*. If the forecast is unbiased but the regression line does not coincide with *LPF*, it must intersect the *LPF* at the mean of A_t. At ranges below the mean realizations are, on average, under- or over-predicted. The opposite tendency applies above the mean. The greater the divergence of the regression line from the *LPF*, the stronger this type of error. The larger the deviation of the slope of the regression line from unity, the less efficient the forecast.

The sample *MSE* can be decomposed as follows:

$$MSE = \sum_{t=1}^{n} \frac{(A_t - E_t)^2}{N} = (\bar{A} - \bar{E})^2 + (1 - \hat{\beta})^2 S_E^2 + (1 - R_{AE}^2) S_A^2,$$

where $\bar{A}$, $\bar{E}$ are the sample means of actual and forecast values; S_A^2 and S_E^2 are their respective sample variances; $\hat{\beta}$ is the slope of the regression line; and R^2 is the coefficient of determination. The first component on the right may be termed the mean component (*MC*), the second the slope component (*SC*), and the third the residual component (*RC*). If the forecast is unbiased, $MC=0$; if it is efficient, $SC=0$. In forecasts which are both unbiased and efficient, *MC* and *SC* disappear, and the *MSE* equals the residual variance (*RC*). *MC* and *SC* can be interpreted as that portion of error resulting from systematic tendencies of the forecast system. In dealing with limited samples of esti-

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and in [11] in March and November. FAO forecasts appear quarterly in [3]. Gill and Duffus, Ltd. [5], published quarterly, is the source of these limited-circulation forecasts.

mates and realizations, the calculated *MSE*'s, their components, and the regression statistics are all subject to sampling variation. Thus, even if the estimates are unbiased and efficient in the population, the sample will show unequal means of estimates and realizations, a nonzero intercept in the regression of A on E, a slope different from unity, and nonzero mean and slope components.

To determine whether the forecasts are unbiased and/or efficient, tests of statistical significance are required. The test that E is both unbiased and efficient is the test of the joint null hypothesis: $\alpha=0, \beta=1$. The test of efficiency is the test of the null hypothesis: $\beta=1$.

To give some idea of overall forecast accuracy, the square root of the *MSE* has been computed and expressed as a percent of the actual mean value. While it is tempting to use the R^2 resulting from the regressions as some measure of forecast accuracy, the R^2 is not a reliable guide since in the above analysis it merely represents errors explained by a linear adjustment of the forecast series.

The Mincer-Zarnowitz technique is not without its difficulties. First, this analysis evaluates forecasts only in terms of systematic errors. It does not establish a criterion for choosing between good and bad forecasts except in a few unambiguous cases where an unbiased, efficient forecast with a small *MSE* can be chosen over a biased, inefficient forecast with a larger *MSE*. More likely is the case where one forecast may have a small *MSE* but a large relative *MC* and *SC*, while another unbiased, efficient forecast (small *MC* and *SC*) has the same or larger *MSE* representing unsystematic errors. In other words, large random errors that cannot be reduced by a linear adjustment of the forecast may result in a low correlation between forecast and actual values and yet have very small mean and slope-component errors.

A second problem is raised by the inherent quadratic loss function arising from use of the *MSE* criterion. One result is that the analysis is symmetric with respect to type of error; that is, a downward or an upward bias or either type of inefficiency is evaluated equally. There is no reason, however, to expect that any of the user's loss functions would be symmetric. For example, from the standpoint of decision makers, planning for more world production (and lower price expectations) than is realized would not necessarily cost the same as consistently underestimating world production.

Coffee Forecast Evaluations

Four annual FAS coffee exportable production forecasts were analyzed[3] for each of the five leading producing countries and for the three regional producing areas (Table 1). In general the statistical tests of the joint null hypothesis for bias and inefficiency indicated that few of the annual estimates could be rejected as being significantly different from the null hypothesis ($\alpha=0, \beta=1$). Except in the case of Brazil, the analysis revealed a tendency to underestimate low values and overestimate large values. However, the results were not statistically significant for any of the cases. For all individual countries and regions analyzed, rejection of the joint hypotheses occurred in 16 percent of the cases: E2, E3, and E4 for Colombia, E1 for Angola, and E1 for the Rest of Africa. The null hypothesis $\beta=1$ was also rejected in 16 percent of the cases: E2, E3, and E4 for Colombia, E1 for Angola, and E3 for the Rest of Africa. This indicated that the main cause of poor performance in forecasting was due to inefficiency rather than bias.

For each forecast mentioned, Table 1 shows the difference between the actual and forecast means, giving the direction of bias, the square root of the *MSE* over the mean of the actuals, and the *MC*, *SC*, and *RC* of the *MSE*. These details are all expressed in percentage form. The last column of Table 1 designates whether the test of bias and efficiency indicates rejection at the 95 percent confidence level.

On the average, the *MC* accounted for 8.1 percent of the *MSE*, the *SC* 12.8 percent, and the *RC* 79.1 percent of the error. Although 81 percent of the estimates showed a downward bias, this bias was statistically significant in only two cases: E1 for Angola and E1 for the Rest of Africa. The square-root *MSE* measure showed that the great majority of estimating errors decreased with each new estimate for that year, as expected. The largest forecasting errors occurred in the Ivory Coast and the smallest in Other Western Hemisphere. The FAS estimates generally were very good by the absolute accuracy standard. This is not surprising since the FAS estimates are made close enough to the harvesting season in most countries and revised often enough that crucial factors such as frosts, droughts, and rain dam-

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[3] The complete results of the analysis described in this and the following section are available from the authors by request.

Table 1. Summary of analysis of mean-square error of FAS short-term forecasts for coffee

Producing Countries and Areas	Forecasts	Decomposition of Error			Square Root *MSE* as Percent of Actual Mean	Forecast Mean Bias	Rejected as Biased and Inefficient
		MC	*SC*	*RC*			
Brazil	E1	4.04%	.33%	95.63%	22.54%	4.53%	No
	E2	.09	6.40	93.51	16.72	− .49	No
	E3	10.55	12.35	77.10	12.44	−4.04	No
	E4	10.75	7.62	81.63	5.86	−1.92	No
Colombia	E1	4.41	5.72	89.87	9.93	2.08	No
	E2	.32	46.93	52.75	6.50	− .37	Yes
	E3	2.24	58.04	39.73	7.42	−1.11	Yes
	E4	9.43	40.17	50.40	6.67	−2.05	Yes
Ivory Coast	E1	.13	.51	99.36	23.83	− .85	No
	E2	1.54	.91	97.55	20.94	2.60	No
	E3	1.50	1.63	96.87	20.40	2.50	No
	E4	.20	2.26	97.54	15.20	− .68	No
Angola	E1	18.49	14.73	66.78	19.67	−8.46	Yes
	E2	5.63	24.74	69.62	13.61	−3.23	No
	E3	4.04	20.41	75.56	9.34	−1.88	No
	E4	.11	19.73	80.16	5.96	− .20	No
Uganda	E1	11.49	3.87	84.64	19.28	−6.54	No
	E2	7.15	5.83	87.02	15.63	−4.18	No
	E3	12.51	8.56	78.93	14.56	−5.15	No
	E4	7.46	12.69	79.85	13.33	−3.64	No
Other Western Hemisphere	E1	.64	12.61	86.76	6.12	− .49	No
	E2	7.43	12.34	80.24	5.99	1.63	No
	E3	4.16	10.29	85.55	5.68	1.16	No
	E4	2.14	2.71	95.15	4.30	− .63	No
Rest of Africa	E1	50.50	3.10	46.40	8.72	−6.20	Yes
	E2	24.37	1.89	73.74	5.94	−2.93	No
	E3	6.56	25.79	67.64	6.34	−1.62	No
	E4	26.52	.90	72.58	5.05	−2.60	No
Asia and Oceania	E1	15.15	4.64	80.20	22.23	−8.65	No
	E2	4.57	10.39	85.04	15.26	−3.26	No
	E3	.96	14.59	84.44	15.52	−1.52	No
	E4	3.95	15.58	80.47	14.63	−2.91	No
All areas except Brazil	E1	16.46	2.32	81.22	5.92	−2.40	No
	E2	4.22	17.61	78.17	4.38	− .90	No
	E3	3.91	18.34	77.75	4.91	− .97	No
	E4	12.78	15.70	71.52	4.88	−1.75	No
All producing areas	E1	.08	.36	99.56	10.57	.30	No
	E2	.95	2.70	96.35	7.71	− .75	No
	E3	9.74	5.98	84.28	6.62	−2.07	No
	E4	15.55	5.88	78.56	4.58	−1.81	No

age can be taken into consideration.

The general tendency for underestimation of actual production could be attributed to a natural reaction of producers to make low estimates of yearly crops with price considerations in mind. Another reason might be that the trend toward more peasant smallholders and smaller producing units [7] has made it more difficult to keep track of production. Finally, price expectations induced by the forecasts may provoke a production response.[4]

The tendency in Brazil to overestimate low values and underestimate large ones can be attributed to the great variability of production in that region. Rourke [10], using essentially the same data, found that 86.13 percent of the total variability in year-to-year changes in all producing areas' production was contributed directly by Brazil. The poor forecasting performance for Colombia was also noted by Rourke. He attributed this result to the diversity of production conditions in that country, with large differences in elevation and climatic conditions making coffee yields difficult to predict. A correction factor accounting for these conditions does not seem feasible due to the random nature of the forecast errors.

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[4] For an analysis of this issue in the context of the statistical reporting of U. S. farm commodities, see Hayami and Peterson [6].

Two areas where the downward bias was statistically significant can be traced to large underestimates in those regions for particular years. For Angola the first annual estimates for the coffee years 1960–61 and 1961–62 showed underestimates of almost 1 million bags each year. This is large considering that Angolan production was around 2.75 million bags in both years—an increase of more than a million bags over the previous years. The same is true for the Rest of Africa for the years 1958–59 and 1959–60. These years are very significant since they mark the beginning of a sharp expansion of output due to increased new plantings during the 1950's as producers reacted to the high prices that existed during the first half of the decade.

The FAS estimates performed relatively well in predicting annual exportable production. However, the analysis was only an initial step in the evaluation of short-term forecasts. Several important questions remain unanswered. More information is needed regarding the precise methods used by foreign agricultural attachés and the FAS in generating their data, to determine how the consistent pattern of underestimation arises. Knowledge of the source of this error should lead to better forecasts by introducing a correction factor into the country estimates. If the reason for this underestimation is the increasing number and size of small- and medium-size producing units, it should be possible to find a correlation between changes in the number and size of growing units and the magnitude of the underestimation.

Another important question left unanswered is the poor performance of forecasts in the case of Colombia. As noted above, the various climatic and elevation conditions prevailing there may make forecasting difficult. But this explanation has not been substantiated to any extent. In addition, it would be useful to test the ability of the FAS forecasts to predict annual production changes rather than total production figures. Finally, a comparative study is needed using the FAS, ICO, and individual producing nations' forecasts to test for relative accuracy and to determine whether the same estimation patterns occur within the different sources.

Cocoa Forecast Evaluations

In analyzing cocoa forecasts, the performance of three agencies could be compared. At least two forecasts were made for 36 of the 37 cocoa-producing regions for which series were available. On the basis of simple comparisons of the mean error, no general preference for either the FAS, Gill and Duffus, or FAO forecasts could be determined. FAS had the smallest percentage error in 17 of the cases, followed by Gill and Duffus and FAO with 10 and 9, respectively. In only seven cases could an absolute preference for a forecast be decided on the basis of smaller percentage errors together with smaller percentage systematic error components. These were distributed three cases each for FAS and FAO, and one for Gill and Duffus.

Several patterns emerged: production forecasts for African countries tended to have a downward bias; yet the proportion of forecasts having errors 20 percent or larger was smaller there than elsewhere. Forecasts for the rest of the world tended to have an upward bias, and more than half the forecasts had errors 20 percent or larger. About two-thirds of all forecasts had slope component errors of 10 percent or more.

The number of cases for each continental group that could be rejected as biased and inefficient on the basis of statistical tests varied between producing regions. For all South American countries, less than half of the forecasts failed this statistical test; for the rest of the world a much higher proportion (roughly two-thirds) could be considered biased and inefficient. Since the South American forecasts were characterized by a percent square root *MSE* as high or higher than the rest of the world's forecasts, South American forecasts are clear examples of cases where large but unsystematic errors pervade a forecasting effort. They are no better or worse than other forecasts for this reason alone, however. This exemplifies the unsatisfying ambiguity that remains after performing this type of analysis.

Table 2. Summary of analysis of mean-square error of short-term forecasts for cocoa

Region	Forecast Agency	Decomposition of Error			Square Root *MSE* as Percent of Actual Mean	Forecast Mean Bias	Rejected as Biased and Inefficient
		MC	*SC*	*RC*			
Brazil	FAS	.27%	19.92%	79.81%	19.75%	1.03	No
	G&D*	.76	13.67	85.56	21.08	−1.84	No
	FAO	.08	10.33	89.59	18.88	− .54	No
Ecuador	FAS	13.93	.39	85.68	21.37	−7.98	No
	G&D	20.15	2.95	76.90	20.88	−9.37	No
	FAO	12.05	7.34	80.61	21.54	−7.48	No
Venezuela	FAS	.43	9.66	89.91	20.07	−1.32	No
	G&D	4.31	7.54	88.15	17.94	−3.72	No
	FAO	4.11	5.81	90.09	19.53	−3.96	No
South America	FAS	.00	.96	99.03	12.25	− .06	No
	FAO	.37	1.37	98.25	11.45	− .70	No
Ghana	FAS	2.01	12.96	85.03	18.19	−2.58	No
	G&D	8.64	44.72	46.64	14.03	−4.12	Yes
	FAO	15.29	67.59	17.11	23.73	−9.28	Yes
Nigeria	FAS	.47	10.83	88.70	22.77	−1.57	No
	G&D	8.79	35.39	55.82	16.20	−4.80	Yes
	FAO	23.14	8.71	68.16	18.88	−9.08	No
Cameroons	FAS	2.76	.01	97.24	9.44	−1.57	No
	G&D	.18	9.40	90.42	7.37	.31	No
	FAO	6.28	72.81	20.91	23.00	−5.76	Yes
Ivory Coast	FAS	13.78	2.87	83.93	19.26	−7.15	No
	G&D	42.37	.57	57.05	13.95	−9.08	Yes
	FAO	37.87	.08	62.05	16.10	−9.91	No
Africa	FAS	3.25	8.00	88.75	15.26	−2.75	No
	FAO	25.48	7.44	67.09	12.17	−6.14	No
Asia and Oceania	FAS	4.43	35.82	59.75	13.64	2.87	Yes
	FAO	33.55	49.05	17.39	17.07	9.89	Yes
All producing areas	FAS	2.36	7.43	90.21	10.71	−1.65	No
	G&D	11.86	41.28	46.86	7.98	−2.75	Yes
	FAO	21.11	10.39	68.49	8.48	−3.90	No

* Gill & Duffus

Some of the more important series, measured in terms of their share of world production, were chosen for presentation here. The main results are shown in Table 2, which has the same format as Table 1. The analysis focused on Brazil, Ecuador, and Venezuela, the three largest South American producers, together accounting for 92 percent of that continent's production over the period; Ghana and Nigeria, the two largest African producers, and the Cameroons and the Ivory Coast, two fast-growing African producers, all four of which accounted for 92 percent of African production over the period; and the totals for South America, Africa, Oceania, and Asia, accounting for 85 percent of total production; and total world production. The results from these important regions are typical of the complete analysis of all countries in the sample.

Many of these series analyzed in Table 2 were inefficient, and the tendency was for forecast errors to be overestimates at large forecast magnitudes. However, a smaller proportion of these large-producer forecasts (under a third) had statistically significant systematic errors as compared to the complete set (where over half could be rejected as biased and inefficient).

On the basis of the results, the analysis of short-term production forecasts of cocoa can be generalized as follows:

(1) South American forecasts did not err systematically, but the general level of errors

was the same or higher than that for countries elsewhere.

(2) African forecasts tended to be biased downward, and where total errors (as measured by the root *MSE* as a percent of actual means) were of the same magnitude or a little less than elsewhere, these errors could in more cases be shown to be systematic.

(3) Inefficiency was of the type tending to associate overestimates with large actual figures. This was true of all three forecasting agency series.

(4) On the basis of statistical tests, the FAS showed less of a tendency to make systematic errors. However, it shared the general characteristics of the other forecasts with respect to downward bias in African production estimates.

Conclusion

On the basis of analysis it cannot be concluded that present forecasting efforts for coffee and cocoa are good or bad, or that, in the case of cocoa, one agency's forecasts are to be preferred over another's. This is an unsatisfying result, which stems from some of the limitations of the Mincer-Zarnowitz procedure noted earlier. However, it was shown that many series contained bias or inefficiency of a particular type or were plagued by large but unsystematic errors. An unresolved issue is how important these various considerations are with respect to the users of the forecasts. Unfortunately this cannot be determined in the absence of adequate knowledge of the cost of forecast errors to the users.

Recent work, especially by Hayami and Peterson [6, p. 128], indicates that investment in the improvement of official forecasts of domestically produced U. S. commodities may have a high social rate of return. However, in the case of coffee and cocoa forecasts, it is not clear that reduction in forecast variance can be directly related to the costs of expanding the current forecasting effort. The reason is that this effort rests on the cooperation of dispersed sources of information that are not always involved in the production of the commodities. On the other hand, it is likely that improvements in data collection involving, for example, tree plantings, acreage, spraying, etc., will lead to the development of structured models for short-run forecasting of coffee and cocoa. Perfection of such models together with a better understanding of the costs of forecast errors to decision makers would make forecast evaluation of the kind attempted here a more straightforward and unambiguous exercise.

References

[1] Food and Agricultural Organization of the United Nations, *Monthly Bulletin of Agricultural Economics and Statistics*, Rome, various issues, 1958–1970.

[2] ———, "Report on Forecasting Techniques for Cocoa Production in the Ivory Coast," Rome, March 6, 1967.

[3] ———, Cocoa Study Group, *Cocoa Statistics*, Rome, published quarterly, 1958–70.

[4] ———, Cocoa Study Group, "Forecasting Techniques for Cocoa Production During the 1967/68 Season in the Ivory Coast," Rome, April 21, 1969.

[5] Gill and Duffus, Ltd., *Cocoa Market Report*, London, various issues, 1960–70.

[6] HAYAMI, YUJIRO, AND WILLIS PETERSON, "Social Returns to Public Information Services: Statistical Reporting of U. S. Farm Commodities," *Am. Econ. Rev.* 62:119–130, March 1972.

[7] KRUG, C. A., AND R. A. DEPOERCK, *World Coffee Survey*, Rome, Food and Agricultural Organization, 1968.

[8] MINCER, JACOB, AND VICTOR ZARNOWITZ, "The Evaluation of Economics Forecasts," in ed. Jacob Mincer, *Economic Forecasts and Expectations: Analyses of Forecasting Behavior and Performance*, New York, National Bureau of Economic Research, 1969.

[9] Pan-American Coffee Bureau, *Annual Coffee Statistics*, New York, 1948–1969.

[10] ROURKE, BLAIR E., "Short Range Forecasting of Coffee Production," Food Research Institute Monograph, Stanford, Stanford University, 1970.

[11] U. S. Department of Agriculture, Foreign Agriculture Service, *Foreign Agricultural Circular: Cocoa Beans*, Washington, various issues, 1956–1970.

[12] ———, *Foreign Agricultural Circular: Coffee*, Washington, various issues, 1963–1970.

[13] ———, *Foreign Crops and Markets*, Washington, various issues, 1946–1955.

[14] ———, *World Agricultural Production and Trade, Statistical Reports*, Washington, various issues, 1958–70.

Dynamic Programming of the Dairy Cow Replacement Problem

BLAIR J. SMITH

The replacement model compares the present values of expected net returns to the keep and replace decisions for cows differentiated as to length of previous calving interval, lactation number, and production in prior lactations. Taking obsolescence explicitly into account, all cows are ranked in order of their future profitability.

DAIRYMEN are constantly faced with the difficult problem of determining the optimal time to cull cows from their herds. Simultaneous account of several biological and economic variables and relationships is critical to the accuracy of cow evaluations for such purposes. The complexity and regularity of culling decisions suggests that use of formal computer decision models be considered.

A decision-determined Markov process with rewards formulation appropriately models the dairy cow culling environment.[1] The dairy cow process is a kind of "slot" in a herd which is always occupied by some cow. The objective is to maximize the present value of expected net returns to that process over a specified planning horizon. This requires finding the optimal keep-replace decision for every kind of cow that is likely to occupy the process when evaluated. This paper briefly reports a dynamic programming approach to this problem.[2]

Most recent related studies of replacement draw their theoretical and methodological concepts and insights from the work by Bellman [1] and Howard [8]. Early applications of dynamic programming to agricultural problems are by White [13], Halter and White [7], and Burt and Allison [3]. More generalized orientations and overviews of the replacement problem and appropriate analytical techniques are provided by Faris [4] and Burt [2]. Two major studies [5, 9] of dairy cow replacement have been made prior to the one reported here, and both are important references in the present work.

Replacement Variables and Parameters

Generalized production prediction model

Since the problem of replacement requires comparing the consequences of keeping a certain cow to the consequences of replacing that cow with another of a given kind, interest is in those factors differentiating between the two. Relationships which "explain" differences in the performance of cows were developed from lifetime histories of 369 Jersey cows and from reports and articles in dairy science literature. Pounds of milk produced in the first 305 days of the lactation and converted to a 4 percent butterfat basis was chosen as the primary measure of cow performance. A generalized production prediction model of the following form was developed:

$$P_n = b_0 + b_1L_3 + b_2L_4 + b_3L_5 + b_4L_6 + b_5I_2 + b_6I_3 + b_7P_{n-1} + b_8P_{n-2},$$

where the P's refer to pounds of milk produced in each indicated lactation, the L's are 0, 1 variables for lactation number, and the I's are 0, 1 variables for length of previous calving interval.

Length of calving interval was determined to be independent of both the number of lactations the cow has completed and the length of calving interval in other lactations. Probability of a cow failing during any given lactation was computed from the basic cow data to be .04212 +.01714 L_n, where L is the lactation number. A cow is considered to have failed if she dies or must be culled for reasons other than a simple inability to conceive, minor udder problems, or low production. If a cow fails, and at any time she has completed six lactations, it is assumed she will be replaced by a heifer beginning her first lactation.

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[1] A Markov process is most simply modeled as a probability tree, where the outcome at any point in time is dependent, at most, on the outcome in the immediately prior point in time. A decision-determined Markov process is one wherein the decision determines which of several possible trees is relevant. In the present case one tree is followed if the decision is to keep, another if the decision is to cull any particular cow. Differential rewards (returns minus costs) may be associated with each kind of cow, present or replacement, that is to be kept. For more information on Markov processes and associated concepts and techniques see [10].

[2] The present article is based on work more fully reported in [12].

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Characteristics by which cows may be classified are referred to as "states," and each time period over which the cow process is to be evaluated is referred to as a "stage." To satisfy the Markov requirement of independence between stages, specific values were assumed for each prior production variable at each stage. The range of possible production levels in each lactation was therefore set at 5,000 to 12,000 pounds, then divided into intervals of 250 pounds. A fixed relationship between production levels in prior and subsequent lactations was assumed. That is, for a given lactation-calving interval transition (which is probabilistic), the expected level of production is deterministic. With 29 values of the state variable for production in each of the two immediately prior lactations, six lactation numbers, and three calving intervals, a total of 15,138 states that the replacement process could be in at any stage were formed.

Characteristics of the replacement cow

Quality of the replacement cow was assumed to be unrelated to the characteristics of the particular cow being replaced and that at any given point in time replacement cows are all of the same quality. In this way, any cow presently in a herd is compared to a common standard, and an ordering of the relative merit of each cow can be effected. To incorporate improvements in the basic genetic capacity of cows to produce milk over time (causing a kind of obsolescence in cows already in the herd), the assumed production of the replacement cow was incremented by 1 percent at each succeeding stage in the replacement model.

Economic components of the replacement problem

Costs and returns that can be assumed to be the same for all cows at a given point in time can be ignored in the replacement decision. Examples are costs of housing, equipment, land, and most of the labor.

Variable returns explicitly included in the replacement model are value of milk produced, salvage value of the cow, and value of calves born. Explicit variable costs are the initial value of the cow and feed. The value of calves born and the costs of feed consumed vary directly with quantity of milk produced. The value of the cow, both at the beginning and the end of each stage, is a function of her production and her age as measured in number of lactations completed.

The replacement model nominally requires that the manager buy into the process at the beginning and sell out at the end of each stage. The actual difference between values at the two times is depreciation, an implicit variable cost. Optimal replacement policy is based on the comparison of the present values of expected net returns to the keep and to the replace decisions. The cow process can be evaluated for any specified number of stages, determined by the length of planning horizon that is of interest.

The Replacement Model

Dynamic programming is the transformation of a large, multistage sequential decision process into a series of single-stage problems that can be solved one at a time. The computational algorithm of dynamic programming is its most unique characteristic. Computation begins at the final stage in the planning horizon and proceeds backward in time, stage by stage, until the present time is reached. The backward recursive relationship that is established for planning horizons of any length can be seen in the system of equations (1) through (3), as follows:

$$\bar{f}_{i(1)} = \max_{d} \left[\sum_{j} p_{ij}{}^{d} r_{ij(1)}{}^{d} + \beta \sum_{j} p_{ij}{}^{d} \bar{f}_{j(0)} \right] \tag{1}$$

$$\vdots$$

$$\bar{f}_{i(n)} = \max_{d} \left[\sum_{j} p_{ij}{}^{d} r_{ij(n)}{}^{d} + \beta \sum_{j} p_{ij}{}^{d} \bar{f}_{j(n-1)} \right] \tag{2}$$

$$\vdots$$

$$\bar{f}_{i(N)} = \max_{d} \left[\sum_{j} p_{ij}{}^{d} r_{ij(N)}{}^{d} + \beta \sum_{j} p_{ij}{}^{d} \bar{f}_{j(N-1)} \right]. \tag{3}$$

In equation (1), $\bar{f}_{i(1)}$ is the maximum present value of expected net returns to the cow process if one stage remains and the process is in state i. The maximization is made over the decision d which can take on the values Keep and Replace. Given a state i and a decision d, there is a probability p and an associated return r for each state j into which the process can be transformed. The products of p and r are summed over all j's to obtain the expected returns for the single remaining stage. To this is added the discounted expected salvage value of the process at the end of the planning horizon. A similar description is appropriate for the generalized equation (2), but instead of the second term being a simple salvage value, it is the sum of the returns for all prior stages. The second term is discounted at each successive stage, effecting the compounding necessary in the computation of present values.

The definitions of the terms in equation (2) are as follows:

$$r_{ij(n)}^{d} = y_{ij(n)}^{d} - g_{ij(n)}^{d} \quad (4)$$
$$= \text{net milk production}$$

where

$y_{ij(n)}^{d}$ = production if the process succeeds, and

$g_{ij(n)}^{d}$ = loss in production if the process fails.

Production if the decision is to Replace and the replacement cow does not fail, is:

$$r_{ij(n)}^{r} = y_{ij(n)}^{r} - g_{ij(n)}^{r} \quad (5)$$

where

$$y_{ij(n)}^{r} = \text{REPVAL}\,[1 + \text{GENPC}\,(N - n)], \quad (6)$$

REPVAL = production of the replacement cow in the first stage, and

GENPC = stage by stage change in the basic genetic capacity of replacement cows to produce milk.

Probable loss in production due to failure of the replacement cow is:

$$g_{ij(n)}^{r} = \frac{q_j y_{ij(n)}^{r}}{\text{PENALTY}}, \text{ where} \quad (7)$$

q_j is the j^{th} element in a vector of the probabilities that the state into which the process is transformed will fail at any stage, and *PENALTY* is the reciprocal of the fraction of a lactation loss due to the time it takes to replace an unplanned (involuntary) removal.

Production if the decision is to Keep and the cow does not fail is:

$$r_{ij(n)}^{k} = y_{ij(n)}^{k} - g_{ij(n)}^{k}, \quad (8)$$

where

$$y_{ij(n)}^{k} = c_{ij} + ay_{n+1} + by_{n+2}, \quad (9)$$

c_{ij} is an element in a matrix of the appropriate constants for production developed from the generalized production prediction model, and y_{n+1} and y_{n+2} are production in the two immediately previous lactations. The y's are subscripted $n+1$ and $n+2$ rather than $n-1$ and $n-2$ so they will correspond to the backward approach of dynamic programming. The coefficients for the two prior production variables a and b are .293 and .380 respectively.

A special case results when the process would progress to the second lactation under the decision Keep as there is no lactation datum for that cow for stage $n-2$. The variable y_{n-2} was arbitrarily set equal to $y_{ij(n-1)}^{r}$ to fill in the data gap.

The probable loss in production due to the failure of the cow kept is:

$$g_{ij(n)}^{k} = \frac{q_j y_{ij(n)}^{k}}{\text{PENALTY}} \quad (10)$$

computed on the same basis as shown for $g_{ij(n)}^{r}$ in equation (7) above.

Equations (5) through (10) are generalized as to state of the process and number of the stage. State of the process at any stage is a function of the state and the decision made at the preceding stage. These factors determine both the states into which the process may be transformed given some present state of the process and the probabilities of each of those transformations taking place. This introduces an additional stochastic feature which seems necessary to a meaningful and useful representation of the cow replacement decision-making environment. Let:

(11) p_{ij}^{r} = the probability of transition from state i to state j for the decision Replace

and

(12) p_{ij}^{k} = the probability of transition from state i to state j for the decision Keep.

Expected production for a given present state of the process under decision d and at state n is then:

$$\sum_{j=1}^{J} p_{ij}^{d} r_{ij(n)}^{d}. \quad (13)$$

Under decision d, many of the elements p_{ij} are 0, since for any given state of the process there are restrictions to the transformations which may take place.

The discount factor is:

$$\beta = (1 + x)^{-1} \tag{14}$$

where x = the stage discount rate.

The general recurrence relation of equation (2) was solved by the value-iterative method.[3] The iterations proceed by computing and storing optimal returns for each possible state with one stage remaining. Then optimal return with two stages remaining is found by selecting the d for each possible state of the process at stage 2 that maximizes the sum of the returns at stage 2 and the discounted optimal returns for the state at stage 1 that results from the decision at stage 2. The computational process is repeated for the third, fourth, etc., stages until the number of iterations equals the number of stages in the planning horizon. Bellman [1] shows that a constant decision policy emerges as the number of stages increases under the value-iterative method. Once convergence has taken place, the associated policy is then also optimal for any greater number of stages. A formal test for convergence suggested by Burt and Allison [3] and by Giaever [5] was not carried out in the present study.

Results of the Replacement Model Runs

Four runs of the replacement model were completed for planning horizons of fifteen stages using the combinations of variable price inputs shown in Table 1. The nonprice variable inputs were the same for all four runs.

Prices used for run one were at the "base" level at the time of the original study (1968). The 20 percent reduction in feed prices in run two brought about a 27 percent increase in net returns for the Replace decision. In run three the 20 percent decrease in milk prices resulted in a 50 percent reduction in net returns. These results were as expected. The effects of the 20 percent increase in beef and veal prices imposed in run four resulted in a slight *reduction* in net returns. Although this was inconsistent with expectations, when it is recognized that over the long run beef prices are probably more important to the cost side than they are to the revenue side of the dairy enterprise, the observed effect of beef price changes is logical.

Table 1. Variable price inputs to the numerical runs of the dynamic programming replacement model

Variable input	Units	Run number 1	2	3	4
Feed price	$/cwt.	4.00	3.20	4.00	4.00
Beef price	$/cwt.	20.00	20.00	20.00	24.00
Heifer price	$/hd.	275.00	275.00	275.00	303.80
Veal price	$/cwt.	23.50	23.50	23.50	28.20
Milk price	$/cwt.	6.50	6.50	5.20	6.50
Interest rate	%/yr.	7.00	7.00	7.00	7.00
Transaction cost	$	15.00	15.00	15.00	15.00
"Replace" returns[a]	$	2,154	2,743	1,065	2,142

[a] These are the present values of the expected net returns to the decision Replace. They are the same for every initial state of the process for any given combination of variable price inputs.

Comparison of the optimal replacement policies for runs one and two revealed that where a difference in policy existed, it was in the direction of earlier replacement. That is, as feed prices declined, cows were replaced at somewhat higher production levels. These differences were of consistent direction and diminished slightly as length of calving interval and lactation number increased. The direction of the effects of a 20 percent reduction in the price of milk on the optimal replacement policy was mixed, though of about the same overall magnitude as that of the feed price decrease of run two. Although the smallest differences in present values occurred with changes in beef prices, here the greatest differences in optimal replacement policies were encountered. Run four, when compared to run one, consistently showed the optimal policy to require earlier replacement when beef and veal prices increased by 20 percent. Sensitivity of the replacement policies with respect to interest rates was not examined.

Conclusions and Recommendations

The optimal decision for any cow for which the relationships, parameters, and variables of a given replacement model are pertinent is provided in the numerical solution to the model. Once a solution to the replacement problem is found for some representative set of factor prices, it probably would not be rewarding to solve it again even if one or more prices change by fairly large amounts. The potential costs to a dairyman for evaluation of an individual cow is largely a function of the number of cows over which the fixed costs of solving a particular model can be spread. This number may be limited to an individual herd or to some group of herds that have certain important characteristics in common. These characteristics in common may be breed, location, level of production, management system, etc.

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[3] Howard [8] also describes the policy-iterative solution routine for planning horizons of infinite length. In addition to the value- and policy- iterative methods, the replacement problem may be transformed into a linear programming format and solved by the ordinary simplex procedure. For information regarding the relationship between linear programming and dynamic programming problems, Hadley [6] and Kislev and Amiad [11] are recommended.

Currently the most promising organizations for the operational employment of a replacement model of the type reported here are the DHIA records processing centers at the state and regional levels. These already have a store and flow of dairy cow data that could provide the information necessary to employ quantitative replacement decision models. Other possibilities exist too, such as commercial farm management or farm record-keeping service organizations.

The most serious weakness in replacement studies to date is in the prediction of production for individual cows. In future work particular attention might profitably be devoted to the identification, quantification, and specification of variables that would improve the reliability of such predictions. The payoff for the incorporation of some measure of cow size, more precise methods for taking account of differing lengths of calving intervals, and the optimal time to replace within a lactation are also in need of further study.

References

[1] BELLMAN, R., *Dynamic Programming*, Princeton, The Princeton University Press, 1957.

[2] BURT, O. R., "Optimal Replacement under Risk," *J. Farm Econ.* 47:324–346, May 1965.

[3] BURT, O. R., AND J. R. ALLISON, "Farm Management Decisions with Dynamic Programming," *J. Farm Econ.* 45:121–136, Feb. 1963.

[4] FARIS, J. E., "Analytical Techniques Used in Determining the Optimum Replacement Pattern," *J. Farm Econ.* 42:755–766, Nov. 1960.

[5] GIAEVER, H. B., "Optimal Dairy Cow Replacement Policies," unpublished Ph.D. thesis, University of California, Berkeley, and University Microfilms, Ann Arbor, Michigan, 1965.

[6] HADLEY, G., *Nonlinear and Dynamic Programming*, Reading, Massachusetts, Addison-Wesley Publishing Company, 1964.

[7] HALTER, A. N., AND W. C. WHITE, *A Replacement Decision Process: An Application to a Caged Layer Enterprise*, Kentucky Agr. Exp. Sta. Bull. 677, 1962.

[8] HOWARD, R. A., *Dynamic Programming and Markov Processes*, Cambridge, M.I.T. Press, 1960.

[9] JENKINS, K. B., AND A. N. HALTER, *A Multi-Stage Stochastic Replacement Decision Model: Application to Replacement of Dairy Cows*, Oregon Agr. Exp. Sta. Tech. Bull. 67, 1963.

[10] KEMENY, J. G., AND J. L. SNELL, *Finite Markov Processes*, Princeton, D. Van Nostrand Company, 1960.

[11] KISLEV, Y., AND A. AMIAD, "Linear and Dynamic Programming in Markov Chains," *J. Agr. Econ.* 50:111–129, Feb. 1968.

[12] SMITH, B. J., *The Dairy Cow Replacement Problem—An Application of Dynamic Programming*, Florida Agr. Exp. Sta. Tech. Bull. 745, 1971.

[13] WHITE, W. C., "The Determination of an Optimal Replacement Policy for a Continually Operating Egg Production Enterprise," *J. Farm Econ.* 41:1535–1542, Dec. 1959.

Communications

PROJECT SELECTION AND MACROECONOMIC OBJECTIVES: COMMENT

In a recent issue of this journal Stephen McGaughey and Erik Thorbecke offered a methodology for combining multiple objectives into a single ranking index for capital project selection [2]. The purpose here is to offer a warning on the uncritical use of the index and to comment briefly on attempts to substitute objective criteria for subjective decision making. This note is less a criticism than an expansion on some of the issues raised in the article.

The ranking index offered is[1]

$$\bar{R}^p = y\bar{Y}^p + b\bar{B}^p + e\bar{E}^p \tag{1}$$

where

$p = 1, 2, \cdots, n$ (identifying the projects to be ranked)

$\bar{Y}^p$ is the income producing effect of project p, defined as the mean of (a) $\overline{BCR}^p$, the ratio of the benefit-cost ratio (BCR) for project p to the mean BCR for the group, and (b) $\overline{SMP}^p$, the ratio of the social marginal productivity of investment (SMP) for project p to the mean SMP for the group.

$\bar{B}^p$ is the balance of payments effect of project p.

$\bar{E}^p$ is the employment effect of project p.

y, b, e are weights selected by the policy maker according to his preference function so that

$$y + b + e = 1. \tag{2}$$

The component variables of $\bar{Y}^p$, $\bar{B}^p$, and $\bar{E}^p$ are discounted at a preselected appropriate rate of interest.

In a footnote [2, footnote 11] the authors give us the first hint of the possible danger in employing $\bar{R}^p$ as a ranking index for project selection. One must choose among BCR, SMP, and their combination in computing $\bar{Y}^p$, and the value of $\bar{R}^p$ is a function of that choice.[2]

The danger lies in the fact that the choice of preference weights is not independent of the particular measure selected as an index of $\bar{Y}^p$. Thus, for example, $\bar{R}_1$ [2, Table 5] assigns the weight 0.50 to $\bar{Y}^p$ and 0.25 to each of $\bar{B}^p$ and $\bar{E}^p$. This is interpreted to mean that the income effect of the project is regarded as twice as important as either its balance of payments effect or its employment effect. But it really only says that $\bar{Y}^p$, as defined, has twice the weight in $\bar{R}^p$ of each of the two other components, as they are defined.

The distinction would be of no consequence if there were no alternative ways to measure $\bar{Y}^p$. But this is not the case. In fact the benefit-cost ratio itself has several other possible definitions [4]. The choice between BCR and some of the other commonly used income criteria for project selection is equally as relevant as that between BCR and SMP or among the several possible definitions of BCR. The internal rate of return (IRR) and net present value (NPV) are two such measures.

It would be interesting to compare the projects discussed by the authors on the basis of IRR and NPV, but since there is no unique relationship between BCR and either IRR or NPV, this is not possible without the original data. Table 1 shows the essential data of two hypothetical projects discussed by McKean [3, p. 111]. The associated BCR's, IRR's, and NPV's are shown in Table 2.

Two benefit-cost ratios are given in Table 2. BCR_1 is the ratio of discounted gross benefits to discounted gross costs. BCR_2 is the ratio of discounted benefits net of out-of-pocket costs to investment costs. Table 3 shows the values of $\bar{Y}^p$ computed from the income criteria of Table 2.

The results of this exercise are that the weights from any preference function applied to $\bar{Y}^p$ based on, say, BCR_2 would give different values of $\bar{R}^p$ if applied to $\bar{Y}^p$ based on BCR_1, IRR, or NPV (Table 3). The values of $\bar{Y}^p$ based on BCR_2 are very close to those based on IRR. This is mentioned by McGaughey and Thorbecke [2, footnote 1]. However, this is due more to a fortuitous selection of projects for comparison than to the inherent similarity of the criteria. Project rankings based on IRR are invariant with respect to the interest rate. Those based on BCR are not, as shown by McGaughey and Thor-

Table 1. Costs and benefits of two hypothetical capital projects, data in \$1000

Year	Investment Costs	Out-of-Pocket Costs	Total Costs	Benefits	Cash Flow
Project A					
0	100	0	100	0	−100
1–20	0	50	50	70	20
Total	100	1,000	1,100	1,400	300
Project B					
0	100	0	100	0	−100
1–20	0	5	5	20	15
Total	100	100	200	400	200

Source: [3, p. 111].

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[1] This is their cardinal index. They also offer an ordinal index which is only partially subject to the technical comments offered here.

[2] We concentrate here on $\bar{Y}^p$, ignoring the possibility of alternative definitions for $\bar{B}^p$ and $\bar{E}^p$. In addition, $\bar{Y}^p$, $\bar{B}^p$, and $\bar{E}^p$ do not exhaust the possibilities for inclusion in an index such as $\bar{R}^p$.

Table 2. Benefit-cost ratios, internal rates of return, and net present values from two hypothetical capital projects

Project	BCR_1[a]	BCR_2[a]	IRR (percent)	NPV[b] ($1,000)
A	1.1	1.7	19	70
B	1.2	1.3	14	28

[a] Discounted at 10 percent. See text for definition.
[b] Discounted at 10 percent.
Source: Computed from data of Table 1.

becke in their Figure 1. There, the relative rankings of projects 5 and 6, and of 7 and 8 are altered when the discount rate is raised from 6 percent to 10 percent. Note in Table 3 of this paper that the $\bar{Y}^p$ based on NPV are not so close, and those based on BCR_1 reverse the order of priority.

The superiority of one criterion over another in measuring the income-producing powers of projects is not at issue here.[3] The issue is that the assignment of a particular set of weights to $\bar{Y}^p$, $\bar{B}^p$, and $\bar{E}^p$ may or may not give the desired balance among income, balance of payments, and employment. Further, there would seem to be no way the policy maker can know whether or not that desired balance is obtained.

But this is largely a technical issue, and as such, there is probably a technical solution to be found. The important issue is the extent to which objective criteria can substitute for subjective decision making. My own view is that the range of substitutability is not very great, but that does not mean we should quit trying.

The role of economic analysis of policy questions is not to reduce them all to a list of mechanical decision rules. The role is to find that subset of the set of policy questions susceptible to technical solutions. The remaining subset of questions, the difficult ones, is left to the policy maker. In playing that role, the economist is and should be constantly testing the objective-subjective barrier. This is the major thrust of the McGaughey-Thorbecke article.

Relating this mini-essay to the proposed ranking function, $\bar{R}^p$, a number of points can be raised:

1. How many policy makers could specify, in advance, a set of weights for the ranking function? That is, how many could appreciate the implications for an investment program of preselecting these weights? It would seem that the policy maker must have the income, employment, and balance of payments effects of a number of alternative sets of projects laid out for him before he could gain that appreciation. The effects would have to be in terms of money units of income, wages, and foreign exchange flows and not only in terms of ratios. If this is true, the need for a weighted ranking function is reduced.

2. How many policy makers would specify the weights if it meant submitting themselves to the discipline of carrying through the investment program specified by the ranking function? This is not really a fair point. The authors never argued that such a commitment is necessary. In fact, in their conclusion, they permit the altering of preference weights. But doesn't this seriously erode the value of the function?

All projects in an investment program are not undertaken simultaneously, and the initiating phase of the whole set could easily extend over the in-office life of the policy maker. His preference weights would be those that keep him in office. They may be subject to frequent change, and at no time would they necessarily coincide with those of society as a whole. The point is not new, but it is worth frequent repetition.

3. How objective is an objective criterion composed of variables that are selected using subjective judgment? The choice among the various income criteria has been discussed. As noted in [2, p. 37], choices among alternative balance of payments criteria must also be made.

The problem of presenting information to a policy maker is to reduce the mass to that which is relevant and absorbable without, at the same time, making his decisions for him. This is never achieved in the ideal. Displaying multiple project criteria in a single ranking function may be going too far. A preferred alternative may be to show for each selected criterion the contribution of each project. The presentation would be in money units (properly discounted) or numbers employed in addition to the standard ratios.

A compromise between a single ranking index and the separate, unweighted display of all selection criteria has been offered by Constable [1, pp. 333, 334]. He suggests that the income criteria for each project, the BCR, be weighted by a coefficient reflecting regional income differences, and the employment criteria for each, the labor-capital ratio (L/K), be weighted by one reflecting difference in regional employment. Thus there are two suggested criteria for project selection.

Table 3. $\bar{Y}^p$ derived from BCR_1, BCR_2, IRR, and NPV

Project	BCR_1	BCR_2	IRR	NPV
A	0.96	1.13	1.15	1.43
B	1.04	0.87	0.85	0.57

Source: Computed from Table 2.

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[3] It is *an* issue, though. McKean [3, ch. 5 and 7] argues that the income criterion for selecting the best *set* of projects is NPV. This will not, however, permit ranking within the set to determine the order of execution. He recommends IRR as a second-best alternative. In general the benefit-cost ratio is not preferred, and he argues BCR_1 is virtually useless. Note the results in Table 2. See also [4].

Income-Equity: $(BCR)\ (Y/Y_i)$
Employment: $(L/K)\ (E/E_i)$

where Y is some measure of average national family income, Y_i is the corresponding measure of average regional family income, and E and E_i are, respectively, indices of national and regional employment.

Clayton points out that "although there are data problems attending the construction of such ratios, and, furthermore, they suffer from being too mechanical and inflexible,[4] they represent an attempt to move the assessment of mechanisation and other investments to a more realistic plane" [1, p. 334].

This suggestion does not attempt to combine all criteria into a single index, but it does modify the criteria using weights which are explicit functions of equity-related variables.

The direct effect of their use is on the regional distribution of projects. To the extent that income and employment are regionally related, national equity and employment goals are also served.

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[4] And they raise the same technical issue as does the McGaughey-Thorbecke index.

References

[1] CONSTABLE, M., "Promoting Employment Through Rural Project Selection," Staff Paper 95, Institute for Development Studies, Nairobi, University of Nairobi, 1971. Quoted in CLAYTON, ERIK S., "Mechanisation and Employment in East African Agriculture," *Internat. Labor Rev.* 105:309–334, April 1972.

[2] MCGAUGHEY, STEPHEN E., AND ERIK THORBECKE, "Project Selection and Macroeconomic Objectives: A Methodology Applied to Peruvian Irrigation Projects," *Am. J. Agr. Econ.* 54:32–40, Feb. 1972.

[3] MCKEAN, ROLAND N., *Efficiency in Government Through Systems Analysis*, New York, John Wiley and Sons, 1958.

[4] PANEL, J. F., "Indicators of Economic Worthiness in Project Appraisal," *Regional Training Course in Agricultural Project Analysis*, Agr. Planning Studies 15, Food and Agriculture Organization of the United Nations, 1971.

PROJECT SELECTION AND MACROECONOMIC OBJECTIVES: REPLY

Two substantive issues are raised in relation to use of the proposed investment ranking function. The first is the assertion that the rankings are not necessarily unique since there may be alternative investment criteria for measuring the effects of an investment vis-à-vis a given economic objective such as income. Hyslop notes ". . . the benefit-cost ratio itself has several . . . possible definitions. . . ." The second issue relates to the manner in which the ranking function, which combines several objectives, is employed by the policy maker. Hence, "displaying multiple project criteria in a single ranking function may be going too far." These two issues are discussed in turn.

To demonstrate project rankings which vary with the choice of investment criteria, Hyslop selects four criteria for the income effect: the net present value criterion (*NPV*); two benefit cost ratios (BCR_1 and BCR_2); and the internal rate of return (*IRR*). There are, in fact, far fewer possibilities than there appear to be at first. Since the stated purpose of our evaluation is to rank projects, the *NPV* is inappropriate unless the projects always have equivalent capital costs. Likewise, since the investment costs of the projects are equal, Hyslop's *NPV* is just another form of the *BCR*, i.e., the net present value per unit of investment costs. To measure the income effect, the choice is between some form of the *BCR* and the *IRR*.

We cannot add here to the polemics between those favoring the *IRR* and those supporting the *BCR*, but two points seem worth noting.[1] First, the *IRR* is justified frequently because a discount rate is not needed for its computation. For international lending institutions which cannot easily obtain a private or social discount rate in each country in which an evaluation is undertaken, the *IRR* is the only alternative for assessing project feasibility. But a selection of at least a limited range of discount rates cannot be avoided by national planning agencies because of the need to choose among alternative growth paths of consumption and investment in medium- and long-term planning. Second, the *IRR* has strong appeal because it is easily presented and understood by policy makers; this is a real advantage over the *NPV* criterion. But this does not justify its use as a ranking device.[2] In our judgment, the *IRR* is a second-best alternative which is used only when a discount rate is not known. It is the investment criterion, not the ranking function, that fails to measure the desired effect and rank the project correctly.

Therefore, we are left with a choice of the *BCR* to measure income effect. The appropriate form of the

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[1] Representative of the two alternative views are those of Seagraves [5] who defends the *IRR* and Harberger [4] who discusses its weaknesses.

[2] The ranking of mutually exclusive projects by the *IRR* will not necessarily yield a maximum present value of an investment budget. Harberger [4] presents a useful example. See also the recent work of J. Price Gittinger [3].

BCR (Hyslop presents three) depends crucially on the investment budget constraint and what is understood to be a benefit from the viewpoint of the project beneficiaries.[3] Costs in the *BCR* are identified with the limited resources of the budget constraint, and benefits are the net returns to the beneficiaries (whether of the private or public sector). Thus the appropriate form of the *BCR* is determined by the specific circumstances in which the projects are being ranked. For example, either the benefits are net of operating costs or the latter are included as costs—both cannot be correct simultaneously.

The *SMP* differs from our *BCR* because it includes some indirect balance of payments effects. We chose an average ranking of the two to reflect the income effect because of information limitations but not due to any disagreement regarding their utility as investment criteria. If all the indirect effects are estimated accurately in either criterion, we would use it as the investment criterion. We contend that if the benefits and costs are well defined and if the discount rate is known (within limits), the *BCR* (or equivalently the *SMP* as a special case of the *BCR*) measures the income effect of an investment.

Interpretation of the weights y, b, and e in the ranking function is important. We agree with Hyslop that these weights do not necessarily represent weights on objectives as obtained from policy makers' (or social) welfare function. If $y = .50$ and b and c are equal to .25, this does not mean that in policy makers' welfare function the income objective is weighted twice the employment or balance of payments objective. More precisely this particular weighting indicates for any project that its ranking for the income effect is weighted twice its ranking for the other objectives. We are weighting project rankings and not the objectives themselves.

Furthermore, we show two ranking schemes: ordinal (which is given minor attention in the comment) and cardinal. An advantage of the ordinal rankings is that the numerical ranking scale is the same for all objectives but, as we point out, the cardinal ranking provides an indication of the relative separation among the projects. We recommend the use of both as complementary methods. Clearly, a useful device for ascertaining how well projects are ranked for many possible weights is to conduct ". . . a parametric test of the sensitivity of the final ranking (R_j) to variation in the welfare weights. . . ." We see the ranking function as an applicable device for combining several objectives.

In any case a simple reformulation of the cardinal version of our ranking function makes it possible to interpret the welfare weights (y, b, and e) as relating directly to the relative importance of the objectives themselves in the policy makers' preference function. Indeed, one can postulate magnitudes of the three investment criteria which correspond to equivalent contributions to the preference function of the policy maker. These "equivalent welfare" ratios can be expressed respectively as Y', B', and E'. The assumption made is that a project's relative contribution to output of Y' is equivalent from the standpoint of the policy maker's desires as a contribution to the balance of payments of B' and to employment of E'. If it is assumed that the contribution to social welfare of projects is proportional to these "equivalent welfare" ratios, our ranking function

$$\bar{R}^p = y\bar{Y}^p + b\bar{B}^p + e\bar{E}^p \tag{1}$$

can be expressed in the cardinal case as

$$\bar{R}^p = y\frac{Y^p}{Y'} + b\frac{B^p}{B'} + e\frac{E^p}{E'} \tag{1.1}$$

since in (1)

$$\bar{Y}^p = \frac{Y^p}{\sum_{p=1}^{n} \frac{Y^p}{n}}, \text{ and } B^p = \frac{B^p}{\sum_{p=1}^{n} \frac{B^p}{n}} \text{ and likewise for } \bar{E}^p,$$

one can relate the average value of the set of projects for each of the three investment criteria to the corresponding "equivalent welfare" value. Thus, let

$$\alpha = \sum_{p=1}^{n} \frac{Y^p}{n} \Big/ Y' \tag{2.1}$$

$$\beta = \sum_{p=1}^{n} \frac{B^p}{n} \Big/ B', \quad \text{and} \tag{2.2}$$

$$\epsilon = \sum_{p=1}^{n} \frac{E^p}{n} \Big/ E'. \tag{2.3}$$

The revised ranking function becomes

$$\bar{R}^p = y\alpha\bar{Y}^p + b\beta\bar{B}^p + e\epsilon\bar{E}^p \tag{3}$$

where the preference weights (y, b, and e) can now be interpreted as reflecting the relative importance of the objectives.

A simple example based on our sample of Peruvian investment projects should illustrate the meaning of the above function. In our sample

$$\sum_{p=1}^{n} \frac{Y^p}{n} = 1.91, \quad \sum_{p=1}^{n} \frac{B^p}{n} = 1.045, \quad \text{and} \quad \sum_{p=1}^{n} \frac{E^p}{n} = .587.$$

If it is postulated on the basis of the policy makers' preference function that

$$Y' = 1.5, \quad B' = .75, \quad \text{and} \quad E' = .40,$$

it follows from (2) that:

$$\alpha = 1.273, \quad \beta = 1.393, \quad \text{and} \quad \epsilon = 1.468.$$

Thus the ranking function is "normalized" so that the weights (y, b and e) reflect directly the relative importance of the objectives.[4]

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[3] Eckstein [1] derives several forms of the *BCR* under alternative investment constraints.

[4] It is, of course, possible to specify the preference function in such a way that the contributions to welfare are not proportional to the "equivalent welfare" ratio. For instance, it could be postulated that the contribution to welfare of each objective (as measured by the corresponding investment criterion) was less than proportional to the value of the "equivalent welfare" ratio. This case would correspond

Finally, Hyslop fears that policy makers may uncritically accept the results of our index or substitute it completely for their "subjective" decision making. Such an index cannot replace this judgment because many noneconomic variables important to the policy maker cannot always be included in a ranking function. Neither do we envisage the policy maker as "preselecting" the weights. Rather, alternative rankings, based on different weights, are presented, and the policy maker alone judges which of the weights and rankings are appropriate—this is the subjective element of decision making which the project analyst cannot supplant. The weakness of just presenting separate rankings for each objective is that the implications of combining objectives or specific projects cannot be visualized.[5] Rather than substitute a mechanical rule for a subjective decision process, we attempt to make explicit a part of such a process.[6] Separate rankings provide only single solutions—our ranking function gives the same information (the separate ranking) and more knowledge as to how investment alternatives are affected as their relative importance is altered.

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to diminishing marginal contribution of each objective to the policy makers' welfare.

[5] From the sensitivity analysis we can identify projects that rank high for many possible weights and can eliminate projects that rank low. Policy makers cannot always obtain this additional information from separate rankings.

[6] Freeman [2] presents an excellent survey of proponents' and opponents' views of using explicit weights in multiobjective ranking schemes.

References

[1] ECKSTEIN, OTTO, *Water Resources Development: The Economics of Project Evaluation*, Cambridge, Harvard University Press, 1958.

[2] FREEMAN, A. MYRICK, III, "Project Design and Evaluation with Multiple Objectives," in *Public Expenditures and Policy Analysis*, eds. Robert H. Haveman and Julius Margoles, Chicago, Markham Publishing Company, 1970.

[3] GITTINGER, J. PRICE, *Economic Analysis of Agricultural Projects*, Baltimore, The Johns Hopkins University Press, 1972.

[4] HARBERGER, A. C., "Survey of Literature on Cost-Benefit Analysis for Industrial Project Evaluation," in *Evaluation of Industrial Projects*, United Nations Industrial Development Organization, New York, United Nations, 1968.

[5] SEAGRAVES, J. A., "More on the Social Rate of Discount," *Quart. J. Econ.* 84:430–450, Aug. 1970.

AN ANALYSIS OF THE MARKET FOR FOOD STAMPS: COMMENT

Professor Bryant's opening statement that "analysis of the Food Stamp Program is not important in itself, for it is one of those programs . . . [that] has been studied too much," is far from the mark [1]. None of the six studies cited is the culmination of long-term serious research efforts; some are not even economic studies, and several deal with broader issues than the Food Stamp Program. With his assertion, Professor Bryant frees himself from program analysis and launches into an "ivory-tower" exercise that leads to inconclusive results. The analysis is based on several misconceptions and loose assumptions.

Certainly, a food program costing the Federal Government $2 billion per year deserves a little attention from our profession. Compare the meager resources analyzing this program with the millions of dollars going into squeezing and massaging the "farm problem" and the $4 billion, more or less, in farmers' subsidies. I am speaking of analytical efforts, not rhetoric, which abounds.

Bryant views Congress as willing to allocate fewer funds in return for a given amount of program expansion at higher rather than at lower program levels. Table 1 shows the historical situation to be the reverse.

Levels of "bonus" per person (amount of subsidy received) in fact have risen because of liberalization in program benefits that occurred in mid-Fiscal Year 1970. That change also completely divorced stamp issuance levels from income of the household.

In practice, Bryant's assumption of arbitrary regulation of growth is meaningless because the program is open-ended. That is, the Government stands ready to provide stamps to all persons who qualify under the eligibility criteria established by law. The quantity of stamps provided now (since mid-1970) depends only upon household size—not the level of Congressional appropriations nor the level of household income. However, the purchase requirement for participation continues to depend on level of household income.

Bryant completely misunderstands this aspect of the program, and his misunderstanding leads him to several erroneous conclusions regarding "pricing policies" and opportunity costs. This problem is

Table 1. Food Stamp Program growth

Fiscal year	Program costs[a]	Recipients	Bonus per person
	Mil. dol.	*Mil. persons*	
1968	179	2.2	$6.52
1969	240	2.9	6.62
1970	565	4.3	10.55
1971	1,559	9.4	13.57
1972	1,896	11.1	13.46

[a] Excludes administrative funds; federal operating expenses in 1972 totaled $21 million.

compounded by the apparent lack of awareness of the "variable purchase" option now available to recipients. The "prices charged," according to his Table 2, in fact vary only because of differences in purchase requirements, not stamp issuance levels that are fixed for given household sizes. The increasing purchase requirement over household size reflects economies over household size and sex-age differences built into the schedule.

Bryant's Table 2 is difficult to interpret. Household stamp issuance data were converted to a per capita basis but, strangely, the income groups were not adjusted accordingly. Bryant ends up with a confusing hybrid concept.

Bryant's related assumption that the Food and Nutrition Service has been cost constrained "throughout its history" is incorrect. In the early years the budget was low and purchase requirements were necessarily high. In that sense there certainly were "constraints." Even then, however, no constraints were in effect for eligible households in areas served by the program. Fund limitations have been meaningful in some years in slowing substitution of this program for the Food Distribution Program. But even this limitation is not now a factor. In Fiscal Year 1972, the Department was criticized in some quarters for not utilizing all its available funds. Since the fall of 1971, there have been no sizable backlogs of areas wanting to initiate the program.

In the context of the way the program operates, it is not meaningful to draw implications about operational efficiency, as Bryant did, from the fact that the Department "has never argued for the same or smaller appropriations." The Congress in Fiscal Year 1972 appropriated more money for the program than was requested by the Department and more than subsequently needed. Bryant fails to realize or appreciate the importance of the distinction between program and administrative funds made available to the Agency.

Bryant overstates the change in program concepts that occurred in Fiscal Year 1970. He interprets the liberalized benefits as a switch from objectives of supporting farm income to an in-kind welfare program. In practice both objectives have been and continue to be important. The program was expanded from a pilot effort to a full-scale substitute for the Food Distribution Program in the early and mid-1960's, with the full understanding of the importance of consumer sovereignty in the marketplace for low-income as well as higher-income people. This transition was well underway before the hunger problem became a national issue.

Measurement of the demand-increasing effects of the Food Stamp Program is still in its infancy. Pilot studies such as the one recently completed by Pat Madden at Pennsylvania State [2] suggest that demand-increasing effects of the Food Stamp Program likely overshadow those of the Food Distribution Program that it is replacing. In addition, there likely are some interesting shifts in demand that can be associated with the switch in programs. These would make worthwhile studies for some underemployed university resources.

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References

[1] BRYANT, W. KEITH, "An Analysis of the Market for Food Stamps," *Am. J. Agr. Econ.* 54:305–314, May 1972.

[2] MADDEN, J. PATRICK, AND MARION D. YODER, *Program Evaluation: Food Stamps and Commodity Distribution in Rural Areas of Central Pennsylvania*, Dept. of Agr. Econ. and Rural Soc. Bull. 780, Pennsylvania State University, June 1972.

AN ANALYSIS OF THE MARKET FOR FOOD STAMPS: COMMENT

This comment on Keith Bryant's article in the May 1972 issue of this *Journal* will unhesitatingly award a plus-mark for effort but regretfully add minus for content. To give analytical attention to programs such as the Food Stamp Plan is obviously desirable. To Bryant's further credit, he began with at least a gesture toward evaluating the Stamp program according to designers' own criteria. But thereafter his reporting became so erroneous as to discredit the initial good intent.

Bryant undertook to show how administrators of the Food Stamp Plan run it for their professional aggrandizement. Cited is a line from Niskanen, naming as variables in the "bureaucrat's utility function . . . salary, perquisites of the office, public reputation, power, patronage, ease of managing the bureau, and ease of making changes" [4, pp. 293–294]. No mention is made of the goals of the program to which the administrator is committed. No room is reserved for acknowledging any personal dedication, for crediting any selfless serving of the public interest. It is a supercilious, Machiavellian interpretation. It is also wrong in many cases (and to the extent it is wrong, grossly unfair).

It is wrong in the case Bryant examines. Holding to the Niskanen nihilism, Bryant postulates that the program could have been operated for either budget-maximizing or modified budget-maximizing objectives. The former would get the most money to run through the till. Prior to 1968 the second would give most support to farm income (the only decent hypothesis offered, but factually wrong) and after 1969 would give most "in-kind welfare."[1] Not even hinted at was the possibility that the program sought to do what it was told to do, namely, obtain the most improvement of diets that was possible within the limits of appropriations.

To natively skeptical economists it probably seems ingenuous that dietary improvement would truly be the objective pursued. Yet, while granting that other considerations were not absent, I must declare that during the early years that was how it was.

It was my good fortune to have a passing acquaintance with the pre-war program and then to join the office of the administrator of AMS just as the pilot Stamp programs were begun in 1961. My vantage point was excellent. After I moved to Missouri in 1966, my first research project was to study supplementary food programs, and I have kept in touch since [2].

Bryant says that until about 1968 or 1969 "the FSP was conceived and run as a device to support farm income" [3, p. 308]. Even to pose farm vs. food goals is an antilogy, for insofar as the program added to food buying (and grocers took only normal margins), it implicitly added to farm income. The two are an identity. If he means that farm income got first consideration in policy making, he is mistaken. It was the other way around.

The Food Stamp law was enacted as a result of a decade-long personal crusade by Congresswoman Leonor Sullivan of St. Louis, Missouri. The law was urban-sponsored. The sole goal as advanced by Mrs. Sullivan, a stern puritan, was to enhance the diets of low income people while still requiring them to contribute their normal expenditure for food. No give-away stamps, no lifting of diets much above minimum nutritional levels. Although Congressman Cooley, Chairman of the House Agriculture Committee, looked kindly on Stamp legislation, his Committee frowned. They brightened up only when Mrs. Sullivan resorted to stratagems such as blocking unanimous consent on farm bills and circulating a legal-sized yellow scratch pad on which urban congressmen affirmed their refusal to vote for any more farm laws until a Food Stamp law was passed. This is not to say that farm support was absent. It was not. But it was secondary.

Bryant is correct in saying that early appropriations were niggardly. It is also true that the puritanical terms of the program kept participation lower than in the parallel commodity distribution. The policy dilemma posed was the following—and it lent itself to mathematical model-building: participation in any area could be increased by reducing the cost of stamps or increasing their monthly face value; yet such action would also reduce the efficiency of the program in enhancing diets[2] and hold down the total number of participants who could be accepted within the fixed appropriation. As new eligible areas were clamoring for the program, the pressure to stick to stern terms was great. Bryant's assertion that "for the period 1964 to 1968 . . . the total quantity of stamps was the program characteristic of primary importance . . ." is just not valid [3, p. 309].

For the later period Bryant is on sounder ground, though it is by no means clear that "aggregate participation" exactly sums the situation. Under fire from partisans of the poor and in reaction to advice of some economists (misguided, in my opinion), the original tenets were scuttled and the program moved toward a combination of welfare and food subsidy. Funds suddenly became much greater. Thereupon the monthly quota of stamps was raised and purchase price reduced. Families could obtain a better diet than they were accustomed to because stamps cost less than their face value, and by spending fewer of their own dollars they saved money for other purposes. To make the changeover more drastic, for the first time a family was allowed to purchase a fraction of the monthly quota of stamps; electing the option reduced the food-buying feature and increased the welfare aspect still more.

This does not mean that nutritional improvement is now absent from the Stamp Plan. A considerable element remains, although the proportion is less and the cost to government for each quantum of improvement is very much greater.

The changes were not brought about by sinister design on the part of program heads. Generally, administrators were lukewarm to the demands for so much liberalization—as indeed poverty spokesmen accused them. Mrs. Sullivan was embittered by the changes and cried, "Look what they have done to my program!" [5] She voted against the 1970 Food Stamp Act.

As the postulates of Bryant's analysis are largely unsupportable, detailed critique would serve little purpose. Some choices he made are questionable, though perhaps not clearly wrong. To consider the effects of the internal design of stamp cost and benefit formulas is of course appropriate. The subject is fertile for analysis. Many of the decisions were *ad hoc* and rule of thumb; they were not as strategically contrived as Bryant believes, but also not as carefully tooled as they might have been. Moreover, Bryant fails to credit as salutary the graduation feature, which is a big improvement over all-or-nothing programs (commodity foods, for one) with their manifest inequity at the margin of eligibility.

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[1] This term refers to a grant of a commodity or service that indirectly becomes an addition to purchasing power for other items.

[2] By efficiency is meant the amount of added food buying per dollar of cost to government. The higher the ratio the more the program classifies as food-supplement. The lower, the more it is welfare in kind.

Subject to being challenged is Bryant's Table 2 for which he converts stamp prices to terms whereby per capita income is standardized for all household sizes. This means that a household of four with a monthly income of $300 is regarded as equivalent to a family of two with a $150 income. The method would be innocent except for the fact that any other assumption, as that a reasonable matching figure for the family of two might be $200, would alter his coefficients and possibly invalidate his conclusions. Frequently in statistical analysis announced conclusions rest on heroic assumptions.

That Bryant began with considerable bias against the Stamp program or government generally is probably a warranted judgment. It is suggested by his reluctance to believe Food Stamp people were not out-and-out grabbers (tested by the "budget maximizing" hypothesis that he says "appears to fit some other federal agencies more closely" [3, p. 313]). In the same vein is his gratuitous observation, hardly appropriate to a scholarly paper, that "an assumption" that "the FSP has been run efficiently" is "dubious" [3, p. 309].

There perhaps ought to be a rule that program analysis should first be done sympathetically. Then on the basis of findings the place of a program in the total scheme of things can be assessed. To view the Food Stamp Plan solely in terms of crass bureaucratic opportunism is as unfair as it is inaccurate.

If researchers want to muckrake supplementary food programs (the family of them), the first place to look is not at administrators' machinations but at local obstructionism based on ideology that it is bad to help people obtain food. This is a point Kotz and other assailants overlook. Any objective assessment of Food Stamp history would turn up very considerable conformity to the avowed objectives of the program. And inquiry into its administration would reveal the mix of performance common to large organizations including universities, with instances ranging from default to dedication and even personal heroism.

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References

[1] BREIMYER, HAROLD F., "Food Programs for Low Income Families—Welfare or Market Building?" Agr. Econ. Paper 1969-28, Univ. of Missouri-Columbia, 1969.

[2] ———, AND HAROLD G. LOVE, *Supplemental Food Programs in Missouri*, Univ. of Missouri Ext. Div. MP 200, 1970.

[3] BRYANT, W. KEITH, "An Analysis of the Market for Food Stamps," *Am. J. Agr. Econ.* 54:305–314, May 1972.

[4] NISKANEN, WILLIAM A., JR., "The Peculiar Economics of the Bureaucracy," *Am. Econ. Rev.* 58:233–305, May 1968.

[5] SULLIVAN, CONGRESSWOMAN LEONOR K., interview with Harold F. Breimyer, July 17, 1972.

AN ANALYSIS OF THE MARKET FOR FOOD STAMPS: REPLY*

Harold Breimyer and Steven Hiemstra have raised a number of questions about my article "An Analysis of the Market for Food Stamps" [2]. Let me summarize what I take to be the significant points and then respond to each in turn.

Breimyer chastizes me for conducting a program evaluation by using improper criteria against which to judge program performance. Breimyer also charges that I have impugned the motives of federal bureaucrats by assuming that they seek to maximize their budgets. Hiemstra denies that the demand for the Food Stamp Program (FSP) is downward sloping and also that the program has ever been "cost-constrained." Both Breimyer and Hiemstra believe my history of the FSP to be in error. On the one hand Hiemstra believes that I have over-emphasized the shift in program objectives from that of farm income support to that of in-kind welfare. He says ". . . both of the objectives have been and continue to be important." In the other hand Breimyer denies that farm income support was important initially and argues that it is even less so as a result of the politics of hunger. Breimyer is bothered by the assumptions underlying Table 2 [2] on the basis of which families were classified by household size and by perperson household income. He says, "the method would be innocent except for the fact that any other assumption . . . would alter his coefficients and possibly invalidate his conclusions." Hiemstra finds my Table 2 hard to interpret and believes that my lack

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* Harald Jensen and Malcolm Purvis read an earlier draft of this reply. Their time and judgment are appreciated but in no way implicate them.

of understanding of the regulations underlying the price structure invalidates the table's contents. In particular he accuses me of not being aware of the "variable purchase option" introduced recently. Both Breimyer and Hiemstra are upset with my comment that I am dubious the program has been run efficiently.

It was not my purpose in [2] to evaluate the FSP. That it was run well or ill by whatever criteria might be used to judge it, could not have concerned me less. The object of the paper was to test a theory. The theory represents an extension of firm theory into the not-for-profit sector of the economy. As was stated in [2] the FSP was used as a case study. Data from any other not-for-profit agency with the same characteristics would have done as well. Those characteristics are that a product is sold to recipients at unit prices and exchanged for a budget from a sponsoring agency. In short then, Breimyer has accused me of doing badly a task I did not set for myself.

Next Breimyer has accused me of maligning federal bureaucrats by assuming that they seek to maximize their budgets. This is a simple, intuitively appealing, behavioral assumption from which empirically testable hypotheses can be deduced. I believe that my paper is a testament to the fact that the hypotheses deduced from the postulate along with the others in the model are empirically testable. Whether maximization of the budget is intuitively appealing depends to some extent on the reader. Niskanen devotes an entire chapter [6, Chapter 4] to a discussion of the assumption. I find his arguments compelling. Briefly, he argues that budget maximization is consistent with utility maximization by the bureaucrat and is not inconsistent with pursuit by the bureaucrat of what he conceives to be the public interest. It is in fact necessary in some degree, for the institutional arrangements within which the bureaucrat must operate impel him to adopt budget maximizing behavior for survival. Finally, Niskanen makes use of Wildavsky's [10] point that both the Executive and the Legislative branches of government expect program administrators to be advocates of the program they administer. Breimyer's comments have not changed my mind about the usefulness of the postulate. He must come up with a simpler postulate which is intuitively appealing and explains the same phenomena or as simple a one which encompasses more of reality. Until someone (including me) does, I will stick with the one I have as imperfect as it may be.

Hiemstra denies that Congressional demand for the program is downward sloped and that the program has ever been "cost-constrained"; his denial constitutes an argument over the shape of the function relating appropriations to program output, TR_a, and the position of the minimum achievable cost function, TC, facing the agency administering the FSP. I postulated them to be conventionally shaped, i.e., the revenue function concave to the horizontal axis and the cost function concave to the vertical axis (with dollars on the vertical and output on the horizontal). I further postulated that the total cost function intersected the total revenue (TR_a+TR_s in the symbols of [2]) at an output less than that which would maximize total revenue; this is the meaning of the term "cost-constrained." These assumptions were made to simplify the analysis without denying any important facts. In addition, I believe that the revenue from appropriations function is conventionally shaped (i.e., the average revenue from appropriations and thence the demand for the program by Congress is downward sloping). This belief is consistent with the fact that the FSP must compete both at appropriations time and when supplemental appropriations are requested with a myriad of other programs each fighting for the marginal appropriations dollar. After some program level is reached, *ceteris paribus*, Congress can be expected to prefer spending the marginal appropriations dollar elsewhere.

The assumption that the program has been "cost-constrained" was invoked to exclude what I consider to be unrealistic cases. If the program were not cost-constrained in the sense I used the term, the *modified budget-maximizing bureau* would operate at an output for which global marginal revenue would be negative (the marginal revenue from appropriations, MR_a, and/or the marginal revenue from the sale of stamps, MR_s, would be negative). Under the same circumstances the *budget-maximizing bureau* would operate where global marginal revenue would be zero ($MR_a+MR_s=0$). Given that positive or zero prices have always been charged for stamps, these results imply that Congress would increase appropriations if program output were reduced. I find no evidence of such a circumstance in the history of the program.

The facts and data Hiemstra marshals to argue against these two assumptions are beside the point. Only if the data on "program costs" and the facts were adjusted to exclude effects resulting from shifts in functions (for instance, shifts in demand as a result of the politics of hunger, rising unemployment rate during the Nixon Administration, and Executive pressures to hold down governmental spending) might they be relevant to the shape of the total revenue curve. When Hiemstra states that in some years appropriations were not used and in others supplemental appropriations were requested and received, he fails to reveal inadequacies in my assumptions. Instead, he reveals the same kinds of adjustment lags in responding to shifting demand that are commonly observed in for-profit firm behavior.

Appropriations were not used in earlier years because of understandable adjustment problems associated with program expansion from the pilot program stage. The result of program liberalization in December 1969 and of the rising unemployment rate during the Nixon Administration was to expand recipient demand for the program beyond what Congress (and perhaps the Food and Nutrition Service) expected; supplemental appropriations were required if the demand was to be met. The more recent example of unused appropriations appears to be a response to a declining demand for all programs by the Executive branch as it has attempted to curb inflation by keeping government spending down.[1]

Comments about the original and later primary objectives of the FSP by Breimyer and Hiemstra not only contradict the judgments I made in [2] but also contradict each other. While Breimyer argues that the FSP was not conceived and run to support farm income, he nevertheless argues that the farm income support goal as applied to the FSP and the goal of increasing food intake of the poor are perfect complements. Hiemstra is quite ready to argue that both increased food intake and farm income support were important in the pre-politics of hunger days. Rather than focussing on selection of the variable, their complaints reduce to a quarrel over my justification of the selection of total quantity of stamps as the important program attribute in the 1964–68 period. They are correct that my tersely stated justification was overdrawn. Increased food intake by the poor and support for agriculture are both mentioned in the preamble to the 1964 act (P.L. 88-525, Sec. 2). The relevance of a food stamp program to both goals was argued by proponents of the program in its early version (1939–43). Both goals were argued by proponents of what was called the National Food Allotment Program in bills introduced in Congress all during the 1940's and 1950's.[2] Similar arguments were made by proponents of the program in 1964 [1, 5, 7, 8, 9].

After the program was enacted, Congress was not concerned with participation in the program until the hunger issue broke into the press in 1967. Nor was Congress all that concerned about adequacy of the diets of the poor, for there was no obvious push to increase coupon allotments to Economy Food Plan levels until the debates over hunger and malnutrition [5, 8]. While liberal and urban Congressmen supported the FSP as an in-kind welfare program (Breimyer apparently does not want to call a food subsidy program an in-kind welfare program), the Agriculture and Appropriations Committees treated the FSP as a farm program to the extent they were allowed to and also as a device to extract urban and liberal support of other agricultural legislation [5, 8]. I conclude that the total quantity of food stamps sold was the important attribute of the program in the earlier period because of both the agricultural support and the food-aid aspects.

That Breimyer understands the basis on which Table 2 was constructed is evidence that Hiemstra's troubles interpreting it stem from his own misunderstanding of what the analysis is about. However, Hiemstra did catch (but did not identify the source) the ambivalence between households and persons which turned out to be an error and which has been corrected in [3].

Hiemstra's contention that I was not aware of the variable purchase option is groundless, for I dealt with it in footnote 3 [2, p. 306] and analyzed its implications for the demand for food stamps in [4]. A question remains, however, as to its impact on optimum price policy since the option was available to participants in some counties in 1971.[3] Unless the introduction of the variable purchase option drastically altered the elasticities of demand to participate in the program, it would still be optimal to charge lower prices to families with low than with high per person household incomes. The optimal relationship between the price of food stamps and household size, holding per person household income constant, depends upon the relationship between household size and per person household purchases of stamps. Under the old system households had to purchase their assigned coupon allotment (quantity of stamps) or not participate. The coupon allotment was determined by their income and size before 1969 and by size only after 1969, with the coupon allotment rising more slowly than size to account for economies of size in food purchasing and consumption. Under the variable purchase option, a household may purchase 100, 75, 50, 25, or 0 percent of its assigned coupon allotment. Unless there is some reason to believe families of different sizes (holding per person household income constant) respond differently to the option (i.e., small families reduce their purchases of stamps more than large families), I know of no reason to alter my conclusions about the optimum price policy. Thus, while the variable purchase option could affect the optimum price policy, I have no information on which to base any alteration of my hypotheses and Dr. Hiemstra has not presented any.

Breimyer believes that an assumption that the price elasticity of demand to participate in the program is not constant among families within the same per person household income class ". . . would alter his coefficients and possibly invalidate his conclusions." He is in error with respect to the coefficients. Their "validity" is independent of assumptions as to their size and sign. Of course different conclusions follow from different assumptions about the price elasticity of demand as they do in any price analysis. In further defense of the assumption, take note that constancy of the price elasticity of demand to participate in the program is assumed among families in the same per person household income class *after adjustments had been made (not by me but by FNS) in the coupon allotments to allow for the existence of economies of size in food purchasing and consumption.* These adjustments remove the reasons I might have had to make other assumptions about the price elasticity of demand for the program. It remains for Breimyer to state the reasons for his objections to the assumption more clearly and/or provide us with evidence on which to base a more realistic assumption.

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[1] The Executive demand for the program has not been well worked into the model. In its present form the TR_a function is formulated after Executive-Congressional bargaining has taken place. See [6, pp. 27–28] on this point.

[2] Harold Breimyer is correct in calling Leonor Sullivan the mother of food stamps. Senator Aiken of Vermont was the father along with certain members of the agricultural economics profession in that they kept the idea alive politically from 1943 until the Kennedy Administration came to power. Mrs. Sullivan did not enter the lists until 1954 [1, 8, 9].

[3] Optimum here means optimal with respect to the objective functions postulated.

Both Breimyer and Hiemstra are upset with my doubt that the program has been run efficiently. By efficiency I mean least cost for given output. My statement was in recognition of the fact that probability is low that *any* not-for-profit agency operates at "least cost" given that it is not exposed to the rigors of the private marketplace where inefficiency can be a source of rapid business failure. Of course I have no evidence to support either my assumption of efficiency (it is implied by assuming that $TR=TC$) or my doubt. My intention was neither to congratulate the agency for my assumption of its efficiency nor to castigate it for my doubt that it was. Rather, it was to note my reservations about an assumption I had made.

Western economists in the neoclassical tradition have concentrated on understanding the behavior of private markets, for-profit firms, and "for-satisfaction" households. But ours is a society and a world in which the not-for-profit (both governmental and private) sectors play important and rapidly growing roles in our economic and political life. Furthermore, horizontal and vertical integration in the private for-profit sector are rapidly internalizing private markets. With the exception of the household, the number and kinds of institutions whose economic behavior we purport to understand and be interested in are shrinking. I believe we are derelict as professionals and careless of our disciplinary future if we do not seek to understand the economic behavior of not-for-profit agencies, public and private, and the economic behavior of markets internal to the multi-layered and multi-faceted corporation. My paper was an attempt to provide some empirical flesh for one of the few extant theories of the not-for-profit sector. That Breimyer and Hiemstra failed to realize this was unfortunate.

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References

[1] ABEL, M. E., AND W. W. COCHRANE, *Policies for Expanding the Demand for Farm Food Products in the United States, Part II: Programs and Results*, Minn. Agr. Exp. Sta. Tech. Bull. 238, April 1961.

[2] BRYANT, W. KEITH, "An Analysis of the Market for Food Stamps," *Am. J. Agr. Econ.* 54:305–314, May 1972.

[3] ———, "An Analysis of the Market for Food Stamps: Correction and Extension," *Am. J. Agr. Econ.* 54:689–693, Nov. 1972.

[4] ———, "Participant Demand Functions for In-kind Transfer Payments," Discussion Paper 96-71, Institute for Research on Poverty, University of Wisconsin, June 1971.

[5] KOTZ, NICK, *Let Them Eat Promises: The Politics of Hunger in America*, Englewood Cliffs, N. J., Prentice-Hall, 1969.

[6] NISKANEN, W. A., *Bureaucracy and Representative Government*, Chicago, Aldine-Atherton, 1971.

[7] SHERMAN, H. R., "Legislative Background of Federal Food Aid Programs," The Library of Congress Legislative Reference Service, S. U. S. F-1, S. 127, Washington, September 1968.

[8] STEINER, G. Y., *The State of Welfare*, Washington, D. C., The Brookings Institution, 1971.

[9] WHETMORE, J. M., M. E. ABEL, E. W. LEARN, AND W. W. COCHRANE, *Policies for Expanding the Demand for Farm Food Products in the United States, Part I: History and Potentials*, Minn. Agr. Exp. Sta. Tech. Bull. 231, April 1959.

[10] WILDAVSKY, AARON, "Budgeting as a Political Process," in *International Encyclopedia of the Social Sciences*, ed. David L. Sills, Vol. 2, The Macmillan Company, 1968 (as quoted in [6, p. 40]).

SEPARABLE PROGRAMMING FOR CONSIDERING RISK IN FARM PLANNING: COMMENT

When a farmer's risk aversion is represented by the Markowitz mean-variance (E,V) criterion, quadratic programming (QP) can be used to derive efficient E,V farm plans and thus array mean and variance combinations for choice by the individual farmer. The population mean and variance for returns for each enterprise are often not available. But QP takes sample means and sample variances explicitly into account. Sample means and sample variances appear as reasonable estimates of the population means and population variances. Thus any other alternative model for generating the efficiency frontier will be less efficient in terms of the Markowitz criterion.

Hazell [1, 3] recommends use of the sample absolute deviation as a substitute for the sample variance in deriving the efficiency frontier. Thomas, *et al.*, [2] have recently used separable programming to approximate the nonlinear total variance constraint and thus derive an approximate efficient E,V boundary. They also have suggested that statistically "insignificant" covariance terms can be removed to reduce model size and computer time requirement. Given the uncertain performance of existing QP algorithms in handling a relatively large matrix, the use of separable programming for empirical farm planning is appealing.

However, it is the user's responsibility to decide a proper grid size for a problem. There is no fixed rule for arriving at grid optima. The grid refinement technique for analyzing and refining results from a particular set of grid sizes may be very important. But this note does not criticize the use of separable programming to approximate the quadratic total variance constraint. Reliability of results greatly depends on the grid size specified and the appropriate piecewise linearization of the nonlinear risk function.

This note questions two points of the Thomas, *et al.*, article: the criterion used to identify statistically "significant" covariance terms to be considered in the model and the concluding comparison of "efficiency frontiers" generated by models using all covariances and by models using allegedly significant covariances.

Statistically Significant Covariance Terms

An efficient farm plan is an organization which for given E has minimum V or for given V has maximum E. The Thomas, *et al.*, model generates the maximum E for given levels of V while maintaining linear feasibility constraints. Separable programming provides a technique for approximating a nonlinear functional equation only if it can be separated into sums and differences of nonlinear functions of one variable. Thus two new variables, Z_{jk1} and Z_{jk2}, are needed for each nonzero covariance term such that the total variance constraint,

$$(1) \qquad \sum_{j} \sigma_j^2 X_j^2 + 2 \sum_{j<k} \sigma_{jk} X_j X_k \leq V,$$

can be represented as a separable function,

$$(2.1) \qquad \sum_{j} \sigma_j^2 X_j^2 + 2 \sum_{j<k} \sigma_{jk} (Z_{jk1}^2 - Z_{jk2}^2) \leq V,$$

together with the linear restrictions on the new variables,

$$(2.2) \qquad Z_{jk1} = \tfrac{1}{2}(X_j + X_k),$$

and

$$(2.3) \qquad Z_{jk2} = \tfrac{1}{2}(X_j - X_k).$$

Reducing the number of nonzero covariance terms therefore greatly reduces the resulting matrix size and computer time requirement. But what covariance terms can be eliminated without too much reduction in the reliability of results? Thomas, *et al.*, suggested that covariance terms be eliminated if their corresponding correlation coefficients are rejected at a 90 percent level of statistical significance. A t test was used to test the significance of each correlation coefficient. At first glance such a test seems theoretically meaningful. However, a small correlation coefficient does not necessarily imply a small covariance value. Likewise, a small covariance value does not necessarily imply an insignificant correlation coefficient. We are concerned about total variance of income and place a restraint on it. A large covariance value seems likely to be more important than a small covariance value. If so, a large covariance term is not eliminated simply because its correlation coefficient is small enough to be statistically insignificant.

The income variance-covariance matrix in the Thomas, *et al.*, example problem [2, p. 263] reveals that in the "significant covariance case," most of the large covariance terms were eliminated while five relatively small covariance terms are included. For example, the returns covariance for corn silage and wheat is 1316.60, while for potatoes and wheat it is −742.40. The elimination of these two covariance terms seems likely to reduce the reliability of the results. On the other hand, the returns covariance for alfalfa and lambs is only −23.20, and for spring stocker cattle and summer finished cattle it is 106.30. To retain such "significant" covariance terms in the separable programming model may be questionable, given the objective of reducing both matrix size and the computer time requirement.

Comparing Efficiency Frontiers

To examine the *effect* of removing statistically insignificant covariance terms, we must compare the efficiency frontier from the model including all covariances with the efficiency frontier from the model divested of covariances found statistically insignificant. It would have been relevant to compare both with the efficiency frontier from the comparable QP model, since separable programming is recommended as an alternative to QP in ranking farm plans in terms of E,V. The efficiency frontier found closer to the latter is more efficient. The distance between them serves as a rough measurement of the efficiency of the results.

No attempt was made in the article by Thomas, *et al.*, [2] to solve the example problem by QP. However, this point is not discussed here. The point is that comparison of the "efficiency frontier" from the all covariance model with that from the significant covariance model, as shown in Figure 2 [2, p. 264], is quite puzzling and misleading. The total income variance restraint, specified as a right-hand side value for equation (2.1), is measured in the vertical axis. The solution mean income value is measured on the horizontal axis. If we use separable programming to approximate the left-hand side of equation (2.1), the actual solution income variance would probably be different from the specified restraint level. The decision maker is usually concerned with the resulting farm enterprise combinations and with the actual solution E, V relationship. Therefore the "efficiency frontier" shown in Figure 2 of [2] is meaningless and obviously wrong in the sense that no curve on that diagram is positioned to show its comparative efficiency. More specifically, the curve on the right need not necessarily be more efficient than the one on the left. If the omitted covariance terms in the significant covariance case were mostly positive instead of negative as they were in the example problem, then obviously mean income would decline less than it would in the all covariance case, as increasing total variance restraints are imposed. That is, the "efficiency frontier" for the significant covariance case would be on the right of that for the all covariance case in that diagram. But it is incorrect to infer from this that the significant covariance model is more efficient.

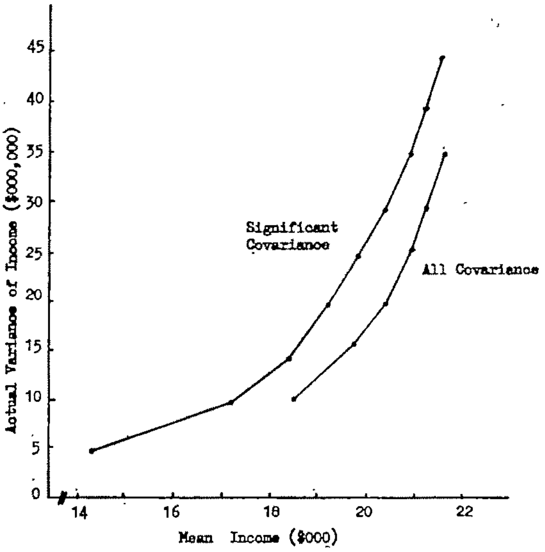

Figure 1. **Efficiency frontier for all and significant covariance models for Thomas, *et al.*, example problem**

Therefore, to facilitate comparison of relative efficiency for all and significant covariance models, we should use the actual variance and mean income from optima generated by separable programming to form a correct efficiency frontier. See Figure 1 of this note. Figure 1 is drawn with information given in Tables 4 and 5 of the Thomas, *et al.*, article. If QP solutions were obtained for this problem, we could draw another efficiency frontier which would be a reasonable estimate of the population E, V boundary. It will be located on or to the right of the all covariance curve in Figure 1. As has been said, correctly, "... the essential problem was to find the most efficient plan in terms of rank rather than to estimate its parameters" [3, p. 506]. The performance of separable programming for considering risk in farm planning should be judged by its efficiency in the selection of a farm plan which has minimum V for a given E.

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References

[1] HAZELL, P. B. R., "A Linear Alternative to Quadratic and Semivariance Programming for Farm Planning Under Uncertainty," *Am. J. Agr. Econ.* 53:53–62, Feb. 1971.

[2] THOMAS, W., L. BLAKESLEE, LEROY ROGERS, AND N. WHITTLESEY, "Separable Programming for Considering Risk in Farm Planning," *Am. J. Agr. Econ.* 54: 260–266, May 1972.

[3] THOMSON, K. J., AND P. B. R. HAZELL, "Reliability of Using the Mean Absolute Deviation to Derive Efficient E, V Farm Plans," *Am. J. Agr. Econ.* 54:503–506, Aug. 1972.

SEPARABLE PROGRAMMING FOR CONSIDERING RISK IN FARM PLANNING: REPLY

Professor Chen has raised two questions concerning our approach to determining the efficiency frontier in farm planning problems. These will be taken up in order.

Her first criticism concerns our use of statistical tests to identify nonsignificant estimates of covariance terms and our subsequent substitution of zero values for those found to be insignificant. Once one accepts E, V efficiency as a criterion for identifying the efficiency frontier, then one of the major problems is to determine the appropriate mean vector and dispersion matrix for the variables which appear in the problem. The case where mean and dispersion parameters are known appears seldom outside the realm of simulation studies. If known parameters exist, they would almost certainly be used. In other cases it may be appropriate to use values reflecting the decision makers' subjective beliefs without any formal use of historical data, irrespective of whether such data are available. Markowitz's work provides an example [1, pp. 26–33]. There may be many other cases in which it is appropriate to assume that the moments of the joint density function which generated past observations on gross margins are appropriate for use in determining an E,V efficiency frontier. At this point the problem becomes one of using statistical inference to estimate the parameters. But obviously the output of this process is a set of estimates and not the parameter values. In cases where there are *a priori* reasons to suspect zero parameter values and where evidence from the sample does not contradict this, then the usual procedure is to accept this conclusion. This is what we have done. Moreover, these procedures are equally relevant irrespective of the algorithm to be used in quantifying the efficiency frontier. It is true that a model with a "less dense" dispersion matrix will usually produce fewer computational problems, particularly when separable programming is used. However, our reasons for removing certain covariance terms concerned the logic of the problem and the properties of the statistical estimates. We do not advocate removal of covariances simply to reduce model size.

Professor Chen suggests that the use of anything other than the sample point estimates of the dispersion parameters will result in farm plans which are not efficient in the Markowitz sense. This is clearly untenable, for if the sample estimates are wrong, then the plans associated with the resulting efficiency frontier may be either efficient, inefficient, or infeasible. For the problem at hand, the researchers' task is to obtain the best possible estimates, and this may result in the use of an array of statistical procedures, both classical and Bayesian. The only universal limitation on the results which we can perceive is that the resulting dispersion matrix be positive semi-definite.

Professor Chen criticizes the results of our decision process on the grounds that it leaves some relatively small covariances in the model while removing some relatively large ones. However, it is clear that size of the coefficients is no measure of their statistical validity. Moreover, one should note that for a given problem of the type under discussion, it is possible to construct an infinite number of fully equivalent problems having fully equivalent solutions merely by changing the units in which the variables are measured. However, in each of the alternative formulations the covariances will take on different numerical values. Thus, any comparison of absolute value is not likely to be very informative.

The second point raised by Professor Chen refers to comparisons of the efficiency frontier from the model containing all covariances to that from the model with only significant covariances. She finds such comparisons "puzzling and misleading." The source of her puzzlement appears to be an attempt to conclude that the farm plans associated with the right-most efficiency frontier in Figure 2 of our article [2, p. 264] are more efficient in the Markowitz sense than those associated with the left-most efficiency frontier. We agree that such an attempt would be meaningless, and we made none. The purpose of Figure 2 was merely to present a graphic statement of the implications of accepting one dispersion matrix rather than the other. Since the two curves and the corresponding two sets of solutions were derived from different problem statements, no legitimate comparison of the efficiency of solutions in one set can be made with the efficiency of solutions in the other set.

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References

[1] MARKOWITZ, H., *Portfolio Selection, Efficient Diversification of Investments*, New York, John Wiley and Sons, Inc., 1959.

[2] THOMAS, WAYNE, LEROY BLAKESLEE, LEROY ROGERS, AND NORMAN WHITTLESEY, "Separable Programming for Considering Risk in Farm Planning," *Am. J. Agr. Econ.* 54:260–266, May 1972.

"DISGUISED" UNEMPLOYMENT ONCE AGAIN: EAST PAKISTAN, 1951–1961: COMMENT*

This paper questions the validity of Robinson's analysis of disguised unemployment in East Pakistan [2] and his conclusions that (1) three million agricultural workers were added as "surplus" labor and were absorbed largely through "work sharing"; and (2) "work sharing" would become impossible and be replaced by overt unemployment once the marginal product per worker is near the subsistence level [2, pp. 600–602].

"Surplus" labor has been defined in the literature as that which makes no positive contribution to output. This definition is also implicit in Robinson's paper, for he argues that three million additional workers who raised the workers per acre ratio from 0.41 to 0.51 were "surplus" since 0.41 was "the point at which negative marginal products began to occur" [2, p. 602]. However, he fails to attach due significance to the fact that output per acre increased on the average from Rs 210 to Rs 240. This increase indicates that the marginal productivity of at least a part of the additional workers was positive.

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* The author is indebted to Mr. D. A. S. Jackson, St. Catherine's College, Cambridge, for helpful comments.

His estimate of "surplus" labor does not therefore conform to the definition of "surplus" labor implicit in the paper.

A look at the data for each district over time shows that additions to the "surplus" labor were overestimated by Robinson. In four districts (Barisal, Sylhet, Mymensingh and Rajshahi) both output per acre and output per worker increased with the increase in workers, so that the total of 1.18 million added in these districts cannot be counted as "surplus." This means that the estimate of "surplus" labor cannot be put at more than 2.4 million. It would be even less if account were taken of some additional workers who could be considered productively employed in other districts where output per acre increased.

Robinson explains that the "surplus" workers were absorbed through "work sharing," that is, they contributed part of the total man-hours which continued to be applied in the same amount [2, p. 601]. He supports his explanation by an illustration of the shift in the average product curve of labor. The construction of the product curves, however, is not warranted by the data which provide no support for his assumption of the underlying homogeneity of the production functions in the various districts [2, p. 594]. The diverse movements in the input-output relations which took place in the districts over the decade, as shown in Table 1, leave no scope for making the above assumption on the basis of which Robinson constructs the product curves to explain "work sharing."

Table 1. Input-output relations in agriculture in East Pakistan, 1951–1961

Number of districts	Workers per acre	Output per worker	Output per acre
5	Rise	Rise	Rise
4	Rise	Fall	Rise
7	Rise	Fall	Fall
1	Fall	Fall	Fall

Source: [2, pp. 596–597, Tables 1–3].

Table 1 also shows that an increase in workers per acre was accompanied by a fall in output per acre in seven districts. This can be interpreted as an addition of workers having a negative marginal productivity. The absorption in seven districts of about one million workers,[1] whose contribution to output was negative, shows that the data do not support, as Robinson claims, the hypothesis that "when workers had increased to such an extent that average product per worker was approaching marginal product and both were near the subsistence level would further work spreading become impossible. Past this point, either negative (or at least below subsistence) marginal products would begin to appear or the institutional arrangements under which added workers were guaranteed a claim against output would begin to breakdown and overt unemployment appear" [2, p. 600]. Since, as Robinson himself assumes, "all additional workers 'claim' at least a subsistence share of total output because of family ties" [2, p. 599], it is only when the average, and not marginal, product falls below subsistence level that increments to workers would become impossible.[2] This is because the phenomenon is basically that of "income sharing," and "work sharing" is only a corollary. In peasant agriculture the limit to the addition of workers is set by the numbers that can be supported irrespective of the productivity of the individuals.

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[1] This shows that Robinson overestimated the addition to "surplus" labor, and not (as Gardner concluded [1, p. 159]) that the data do not at all establish the existence of "surplus" labor. In districts where output per acre fell but land area increased, the number of workers added with negative marginal productivity has been calculated as:

$$\Delta W - \Delta L(W/L)_{1951}$$

where the term $\Delta L(W/L)_{1951}$ represents those additional workers who are assumed to have found productive employment on new land.

[2] Robinson's own analysis shows negative marginal products in each year. In 1951 they appear in eight districts. In 1961 they appear in four districts and not in two as he shows. The estimates of marginal output per worker shown in Table 4 [2, p. 598] are incorrect. Given the AP functions,

$$AP = 1107.17 - 1447.40W \quad (1951)$$

and

$$AP = 756.93 - 598.85W \quad (1961),$$

the marginal product functions should be:

$$\text{for 1951 } MP = 1107.17 - 2894.80W$$

and

$$\text{for 1961 } MP = 756.93 - 1197.70W.$$

The marginal products estimated from these functions show that Robinson mostly overestimated.

References

[1] GARDNER, B. L., "Surplus Labour in Rural Pakistan: Comment," *Am. J. Agr. Econ.* 52:158–159, Feb. 1970.

[2] ROBINSON, W. C., "'Disguised' Unemployment Once Again: East Pakistan, 1951–1961," *Am. J. Agr. Econ.* 51:592–604, Aug. 1969.

"DISGUISED" UNEMPLOYMENT ONCE AGAIN: EAST PAKISTAN, 1951–1961: REPLY

Dr. Mujahid's comments fall into two categories. First, he denies the basic validity of the effort to use cross-sectional district-level input-to-output relationships to construct a national average production function. Such an approach does undoubtedly constitute a kind of econometric "act of faith," but it is not original or unique in the literature to the article under review. In any case, it is not a damaging criticism of the homogeneity assumption to show that the labor-land-output ratios changed differently in different districts. If we feed a group of animals a certain nutrient, some will increase their output, some will not, and others may show no change. But the average relationship still has meaning. Indeed, that is what regression analysis is all about. What we are looking at in 1951–1961 is the average response of output to changes in labor per unit of land.

Second, Dr. Mujahid seems not to have understood my poor efforts at explanation of the method. Thus he argues that because yield per acre and total product rose while workers per acre were increasing, this is proof that the marginal product per worker was positive. One of the points of the article is to suggest that the mechanism which leads to this is an adjustment in average input per worker. Marginal product per worker is kept positive by reducing hours worked per worker. A similar confusion seems to have arisen with regard to the final limit to work-sharing. What the article means to say is that average and marginal product per worker approach each other under such very great population pressure (and work-sharing) that both tend toward subsistence.

Finally, I do not seem to have made clear the basic point of the exercise: work-sharing will occur when income-sharing occurs, provided leisure has any value and that this is a rational response to growing density on fixed land. I regret that Dr. Mujahid fails to see this.

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Book Reviews

Cooper, Charles A., and Sidney S. Alexander, eds., *Economic Development and Population Growth in the Middle East*, New York, American Elsevier Publishing Co., Inc., 1972, xvii + 620 pp. ($19.95)

This book represents the third of five studies programed jointly by the Rand Corporation and Resources for the Future Inc. on the economic and political problems and prospects of the Middle East. About two-thirds of the book is devoted to seven separately authored country or area analyses: Egypt (Bent Hansen), Israel (Michael Bruno), Lebanon (Albert Y. Badre), Jordan (Michael P. Mazur), Iraq (Albert Y. Badre), Syria (Bent Hansen), and the Arabian peninsula countries and principalities (Edmund Y. Asfour). The area analyses are followed by two studies of fertility patterns and determinants, one mainly considering the Arab Countries (T. Paul Schultz) and the other focused upon Israel (Yoram Ben-Porath). Finally, there are two brief chapters which comment upon the process of adoption of new agricultural techniques (Fawzi M. Al-Haz and Salah M. Yacoub) and the process of modernization (Samir Khalaf) in the context of Lebanon. Charles A. Cooper contributes a short but incisive introductory chapter.

Each of the country studies is developed on a similar format wherein the authors review the record prior to the 1967 crisis, attempt to predict potential trends in output and likely trends in population over the next ten- and thirty-year periods, and then evaluate the prospects of the countries realizing their estimated potential rates of growth. Projections are made on the assumption that a peaceful settlement of the Arab-Israel conflict will be reached in the not-too-distant future.

Because of the varying quantity and quality of the data base available to the different authors, the presentations vary from an exercise in selective mass macro-manipulations and confident future speculations in the treatise on the Israeli economy, to an assemblage of courageous estimates and cautious interpretations and projections in chapters devoted to such economies as Syria. This country-oriented part of the book does, however, bring together much near-current comparative economic data and informed observations on each of the countries treated and presents this in a generally more rigorous analytical context than will be found in most present alternative source books. The two demographic chapters, likewise, represent an important source of information on population trends in the region and suggestions regarding the main factors affecting fertility (especially in Egypt and Israel) and, in a less definitive sense, the likely consequences of continued high rates of population growth. The final two chapters representing additions to the growing body of literature on the process of modernization have as much general relevance as they do to the Middle East in particular.

The relatively large share of the book devoted to Israel both records the impressive economic achievements of that economy and comments upon many of the conditions upon which this has been based and upon which future economic development and security depend. The generally stimulating influence of the 1967 war, the critical significance of a high rate of investment, the role of immigration, and the importance of an industrial structure and manpower development strategy more closely geared to the country's major market opportunities and cultural ties in Western Europe and the United States are clarified in the treatment. On the demographic side, the dilemma posed by low levels of fertility on the part of the higher income local Jewish population relative to fertility levels of the non-Jewish population of both Israel proper and the administered areas is made more apparent as is the significance of the Soviet Union as a potential source of additional desired immigrants. Overall the future of the country, in spite of its inhospitable regional environment, is viewed optimistically by the authors of the chapters concerned, and full economic independence—an ability to continue to grow without continued outside financial aid—is predicted by 1980.

More interesting and informative to most readers will probably be the chapters on the less well publicized and analyzed economies of the Arab countries included in the study. In general they are all excellent analyses within the data constraints that have confronted all of the authors. The overwhelming conclusion that emerges is that the past records and future growth prospects of most of these countries are not half bad. As one of the editors notes: "The Middle Eastern countries should, on the whole, be viewed as examples of past development success," and "with the possible exception of Syria," they all warrant "the presumption of satisfactory future growth." A 6 percent rate of growth is considered to be a realistic target in most cases. Beside numerous references to the generally deleterious impact of the crisis with Israel on most of these Arab countries and to the demographic issue, many additional topics of development interest are discussed. These include the immediate importance of the Yarmuk project and the Euphrates Dam to the development prospects of Jordan and Syria; the limits to land development at the extensive margin and the particular significance of this to the Syrian economy; the generally difficult problem of modernizing traditional agriculture and its pervasive importance in the developmental task facing the region as a whole; the broader problems of organization and management that are critical to the needed upgrading of the efficiency of investment both in agriculture and industry and the interrelationships between this issue and Arab socialism; the role and significance of oil in the Arabian Peninsula and in the development strategies of Iraq and Syria; and the great contrasts that do in fact exist between the several economies analyzed, Arab though they all be.

The book is unquestionably an important contribution to the better understanding of all the countries analyzed and should be of particular interest to students of comparative economic development. The introduction by Charles A. Cooper stands on its own as an excellent brief on issues in economic development; the book is not primarily an agricultural sector reference, but it does supplement other materials, especially the first volume in the same series of studies. The relative role and significance of the agricultural sector in future development projections receives treatment in each of the country studies.

The main criticism to be leveled at the book is not with respect to what it does but what it does not do. It does not go nearly far enough as a regional study. Important countries such as Libya and the Sudan, not to mention non-Arab countries other than Israel —like Turkey and Iran—are excluded from any consideration. More importantly, however, with the exception of the interregional study of fertility and Bent Hansen's cross-references between Egypt and Syria, most of the truly regional interpretation is left to the reader. This no doubt was the intention of those who planned the study and has a certain merit. However, one might have expected a greater part of the book to have been devoted—without loss of objectivity—to a systematic treatment of the record and potentialities inherent in regional economic cooperation among the countries of the area (with or without the participation of Israel). At least a chapter on past, present and potential interregional commerce and finance would have served as a vehicle for a broader multi-national perspective with at least as much justification from an economic development point of view as the emphasis given to the study of fertility patterns and determinants. Likewise, "hot potato" though it be, an attempted economic cost-benefit analysis of the 1967 war and its aftermath with respect to the different countries in the region might have produced some interesting food for thought for those interested in working toward a resolution of this basic issue that was purposely swept under the rug as part of the methodological terms of reference of the study. In his introduction, Cooper begs the issue by saying that for any assessment of "the full impact of the Middle Eastern crisis on the future economic development of the area . . . art rather than science is called for." The fact is, however, that more of it is susceptible of being clarified by objective inquiry than was attempted in this most relevant unit in the total set of five studies. The remaining two would have benefitted from having had the issue addressed more specifically in the context of this particular work.

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Gregory, G. Robinson, *Forest Resource Economics*, New York, The Ronald Press, 1972, viii + 548 pp. ($12.50)

There are now three modern textbooks from which instructors of upper division and graduate level courses of forest economics may choose rather than write their own syllabus. Not only are there now three (the first was Worrell's in 1959 [2] followed closely by Duerr's in 1960 [1]); but all are good in their own ways. Gregory's book, however, may represent a welcome middle ground for those who want something a little less heavy on production theory than Duerr's, yet a little more expansive on the new welfare aspect of forestry than either Duerr's or Worrell's. Furthermore, students should appreciate its readability since it is markedly less professorial in tone than either of its predecessors; in fact, it is downright frivolous in spots. At any rate, because it is the first new text in its field in a decade, it should attract considerable attention.

Although newly published, Professor Gregory's book is, to a point, a fairly traditional presentation of the subject of forestry economics. In this respect, it can be viewed as commentary on the state of development of this field of applied economics. "Forest resources" turn out to be mostly timber since nearly three-quarters of the text deals with timber production, prices, and wood products. However, unlike the earlier works of Worrell and Duerr who treated such forest products as recreation and wildlife as interesting but tangential topics, Gregory brings them out for equal billing as part IV, "Non-Timber Products Economics." Further, the text is not highly quantitatively oriented nor does it incorporate the more sophisticated tools of management science.

Forestry economics is rationalized as a special field of economics by the pervasive (and perhaps perverse) ". . . biological nature of the resource itself and by the time span involved in forest production." Thus, students of forest economics often have a surprisingly (surprising at least to many of their more "pure" colleagues studying agricultural economics) superior understanding of the arithmetic and application of compound interest.

Although courses in forest economics customarily require advanced undergraduate standing of the students and at least a solid series of "principles of economics" coursework as a prerequisite, economics is usually reintroduced at several points in the course at an elementary level and decorated with forestry–related examples. Gregory follows this penchant for reteaching economics, perhaps anticipating the low infection rate of most forestry students following exposure to an achingly dull "principles of economics" course endured in their freshman year. Professor Gregory is a bit more organized and explicit about this, however, than either Worrell or Duerr. He actually labels the 47-page "Part I" of the book "Review of Economic Principles." He warns the reader that the primary emphasis of this section and the text is micro- rather than macro-economics; and it is in both instances.

Two topics which may be of special interest to forest economists for the purpose of comparing Professor Gregory's text with its predecessor are taxation and stumpage valuation for pricing. Worrell has very little to say about forest taxation; Duerr and Gregory provide two and one chapters respectively on the topic. Gregory's treatment is very similar in part to Duerr's, although it is less detailed and more cleancut in organization. The discussion of capital gains taxation is the strongest point of the chapter on taxes and contains a plea for averaging gains, an admittedly difficult administrative challenge, but an approach which might encourage more intensive utilization and management of timber resources.

Professor Gregory's presentation of the theory of stumpage price formulation is clearly a major improvement over that of both Duerr and Worrell. He provides students (and professors) a singular service by developing frameworks for stumpage valuation that are much more revealing and rigorous than the simple residual value or economic rent methods usually taught. As he points out, these more traditional approaches are stumpage purchaser oriented, biased toward demand analysis, and generally unsuited for evaluating supply especially when stumpage suppliers exercise a reservation price strategy. Housing demand, log exports, mixed forest land ownerships, location, alternative market structures, taxes, and other forest users are all current and continuing American forestry policy issues which are woven into stumpage price analysis by Professor Gregory.

Finally, forestry economics is given resource economics legitimacy by Gregory's analysis of multiple use forestry and wildlife, water and recreation aspects of forestry. However, the legitimacy clincher is provided by the chapters on "Public Production and Welfare" and "Benefit Cost Analysis." These subjects are seldom treated explicitly in forestry economics courses. Forestry students must therefore rely upon elective or graduate coursework taken in agricultural economics departments. This is a near tragedy which Professor Gregory's text may help to avert since the "new issues" of American forest management faced by the new forestry graduate students are squarely within the province of welfare and resource economics. Gregory does not, understandably, provide answers to all of the questions to which he directs the attention of the reader; but the questions which relate largely to public policy are a major contribution.

Tacked onto the end of the book is a chapter on international trade and economic development in forestry. Those who know about Professor Gregory's extensive activities in international affairs will be disappointed in the small size of this window on an increasingly important area of involvement of American foresters. However, the disappointment should be tempered with the realization that this could be the subject of another text.

No book, of course, will appeal strongly to all readers. Professor Gregory's text, in spite of its considerable contributions, lends itself to criticism largely because it attempts too much and thus widens its circle of potential critics. This may mean that it will be a text which offers more than can be accommodated in a single course in forestry economics. Further, experts in each of its many topics will be numerous and will undoubtedly find an X, Y or Z that the author neglected while he discussed A, B or C.

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References

[1] Duerr, William A., *Fundamentals of Forestry Economics*, New York, McGraw-Hill Book Co., 1960.

[2] Worrell, Albert C., *Economics of American Forestry*, New York, John Wiley and Sons, 1959.

Hayami, Yujiro, and Vernon W. Ruttan, *Agricultural Development: An International Perspective*, Baltimore, The Johns Hopkins Press, 1971, xiv + 367 pp. ($10.00)

This book represents an attempt to employ microeconomic theory to advance the understanding of the process of agricultural development. In the authors' view the perspective they outline represents a serious challenge to much of the doctrine and ideology that has dominated recent development theory and policy (p. 306). Their target in this assertion is the macroplanning perspective that has dominated postwar development thought and that emerged from the Keynesian revolution.

The authors identify the capacity to develop a technology consistent with environmental and economic conditions as the single most important variable that explains the growth of agricultural productivity of nations. They postulate a theory of induced development that gives a major role to factor prices in explaining the innovative activities of public sector research institutions in producing technical change. Their investigation into the process by which public sector research responds to economic and social forces leads them to a consideration of the process by which institutions more generally evolve in response to economic and technical opportunities.

The text of the book is divided into five parts, and there are four appendices containing most of the basic data used in the analysis and a description thereof. Part I, titled Problems and Theory, contains a concise review, integration, and synthesis of the various strains of agricultural development thought as they have evolved in the postwar period. The first of two chapters is concerned primarily with the role of agriculture in economic development theories and gives particular attention to the more recent growth stage and dual economy literature. A major thesis of the authors is that most development economists concerned with agriculture have concentrated on identifying the role of agriculture in the total development process, to the neglect of attempting to understand the agricultural development itself.

The following chapter, which takes a longer historical perspective, reviews the presently available theories of agricultural development per se. This review deals successively with the conservation model, the urban-industrial impact model, the diffusion model, and the high pay-off input model. The scholarship in this chapter is of a high order, and almost anyone concerned with agricultural development can benefit from a careful reading and study of its content.

This chapter terminates with a preliminary specification of the Hayami-Ruttan induced development model. This model is basically a theory of technical change and is based on the division of technological processes into two classes: mechanical processes, on the one hand, and biological and chemical processes, on the other. In the authors' view, mechanical equipment is viewed primarily as a substitute for labor, and "evolution of the mechanical equipment is designed to bring about larger output per worker by increasing the land area which can be operated per worker" (p. 50). Fertilizer, on the other hand, is a substitute for land, and "the new husbandry techniques or the new seeds in which new biological and chemical technologies are embodied can be viewed primarily as the inputs which facilitate the substitution for land of artificial sources of plant nutrients, either purchased or produced by more labor-intensive conservation systems" (p. 53).

The multiple paths to technical change which these alternative processes make possible provide the basis for a theory of induced technical change. Such a theory is not new, as the authors recognize (p. 55), but their extension of the theory to include the innovative activities of the public sector is. And this is one of their major contributions.

Part II of the book contains two chapters which analyze the productivity differences among countries on almost a world-wide scale. In the midst of this empirical work the authors specify their induced development model more rigorously by the use of a metaproduction function which accommodates differences in technology, and by hypothesizing that technical change will evolve in response to resource endowments and factor prices, and in such a way as to economize on the scarce resource. In this way technical change serves to break down the barriers to further agricultural development.

Part III contains a detailed analysis of agricultural growth in the United States and Japan. These two countries typify the two extremes of labor-saving and land-saving technological processes, and data from them are used to test the induced development hypothesis. The second chapter of this part, titled Science and Progress in Agriculture, contains detailed historical descriptions and analyses of how science and technology were applied to the agriculture of these two countries. This chapter is fascinating reading, perceptive, and quite insightful. One cannot help but admire the enormous intellectual effort involved in reviewing the literature and synthesizing it into a meaningful whole.

Part IV poses the question, "Can Growth Be Transferred?" The first of its three chapters deals with the Theory and History of International Technology Transfer. The second is a Perspective on Induced Transfer of Technology, which provides (a) an induced development hypothesis for the new cereals technology, (b) an analysis of the transfer of rice production technology from Japan to Taiwan and Korea, and (c) a discussion of the implications for the recent development of high-yielding varieties in the tropics. The third chapter is concerned with Technology Transfer, Trade, and Agricultural Transformation.

The final part of the book is concerned with Retrospect and Prospect. The first of its two chapters is concerned with Disequilibrium in World Agriculture and points out that the large productivity and income differences among countries are prima facie evidence of a massive disequilibrium in world agriculture. The authors explore how this disequilibrium arose in the postwar world and then attempt to use the induced development model to illuminate a number of major considerations in the development of effective agricultural development policy. This chapter contains a good critique of policy in both the developed and developing countries.

The final chapter deals with Agricultural Transformation and Economic Growth. In it the authors draw out the implications of their analysis and make their policy recommendations. The tone is one of moderate optimism, and the emphasis is on how institutions, as well as science and technology, can be mobilized to serve development objectives. However, there is a warning that the opportunities for agricultural development that now seem apparent with the Green Revolution will not be easily obtained.

This book is destined to be one of the landmarks in the development literature. As the above description of its contents indicates, the subject matter coverage is great. The book represents an unusual combination of theory, historical and cross-country analysis, and an extraordinary grasp of an enormous body of literature. Its scholarship is vast, and the analysis is insightful, relevant, and provocative. It represents a significant effort of synthesis, suggests a number of helpful new ways of looking at old problems, and makes important empirical contributions in its own right. Although there is bound to be disagreement with many of the arguments and hypotheses presented in the book, it will serve as a point of departure for much additional work, and even those who disagree with it will have to honor and respect it.

It is difficult to do justice to the book in the space permitted in an ordinary review. However, the following comments may help focus on some of the major issues and serve as a point of departure for a more extended discussion which hopefully will follow in the literature:

1. Their theory provides the basis for extending trade and development theory in an important way. Presently received doctrine does not tell us how the technological state of the world is determined and hence has little to say about inter-country differences in productivity, or what is almost the same thing, inter-country differences in income levels. In the Hayami-Ruttan model, technology becomes an endogenous variable and is explained in large part by relative factor endowments.

2. The linkages which Hayami and Ruttan postulate between farmers, research institutions, and the kind of technology which is generated and adopted is one of the most insightful, and perhaps ultimately, most useful aspects of their analysis. (It will probably also be the most controversial!) It is rich in policy implications, particularly with respect to how to organize an effective research organization.

3. In this reviewer's opinion, however, it is a mistake to imply that a theory of induced technical change is a theory of agricultural development. The authors' conception of agricultural development is much too narrow and begs many of the really important questions. The failure to translate the implications of the technical change into explanations of the income of rural people is of special concern.

4. The lack of attention given to education is somewhat surprising, even accepting the authors' concern with technical change as contrast to per capita incomes. Moreover, it is worth noting that the linkages between economic conditions and institutions which they postulate offer considerable promise as basis for understanding why some societies invest in education while others do not, as well as why individual societies stress the kind of education they do.

5. Even as a theory of induced technical change, however, the model is incomplete. It emphasizes factor prices and resource endowments and as a result is quite useful in explaining the *direction* which technical change takes in the resource-resource dimensions. However, it says little about either the rate at which technical change is adopted, or the extent to which it is adopted, both of which are important if technology is in fact to become an endogenous variable within the system.[1]

6. One of the puzzles in the Hayami-Ruttan framework is the asymmetric treatment of land, labor, and capital in their model. They are concerned with land and labor as barriers to agricultural development. Their analysis focuses on these two primary factors of production and rather leaves capital to the side.

The lack of symmetry in the treatment of land, labor, and capital imposes serious limits to the applicability of their model. This can perhaps best be illustrated by the development problems of a country like Brazil, in which neither land nor labor are barriers to output expansion. If one were to take the Hayami-Ruttan model at face value, there would be no basis for technical change, since both of the primary resources are in relatively abundant supply. Yet surely this is wrong, and surely Brazil has a great deal to be gained by generating and adopting new production technology, if for no other reason than its importance as a source of income streams.

It is unsatisfactory to say that the generation and adoption of technology under these circumstances would be outside the confines of the induced development model. If capital is the limiting resource, then the production technology should economize on the use of this resource, and not on either land or labor. However, we seldom conceive of technical change as economizing on the use of capital, and certainly Hayami and Ruttan do not. Yet, making the limited supply of capital more productive is a rather common and important problem in developing countries. Moreover, many of the employment problems such countries face are a result in part of adopting technology which has been developed in a labor-scarce, capital-abundant economy. The question this reviewer would pose is whether we leave capital-saving technology out of our models by historical accident, or whether there is more to it than that.

7. Chapter 8 on the theory and history of interna-

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[1] A Brazilian economist, Ruy Miller Paiva, has stressed this aspect of technical change in a recent paper [1]. This paper is available in English from the Department of Agricultural Economics, Purdue University (mimeographed).

tional technology transfer is rather narrow in scope. It concentrates on the foundation-sponsored International Centers in México (CIMMYT) and the Philippines (IRRI), and largely ignores the major institutional development efforts of the USAID, the United States universities, and the foundations. It seems clear that these institutional development efforts have been directed to Hayami and Ruttan's third phase of international technology transfer: capacity transfer. Important increases in the indigenous capacities to train researchers, and in the stock of researchers, have been brought on stream as a result of these programs. Although not producing the dramatic short-run impact of the new cereals, this increase in trained manpower and in the installed capacity for training and research is what will likely produce the bulk of the adaption of new technology to local conditions in the next decade.

* * *

It is no discredit to Hayami and Ruttan that they have not solved all our problems. They have set the base for a great deal of additional theoretical and empirical work, and we are certainly much closer to understanding the development process as a result of their efforts. Their book will serve as a useful reference for students of agricultural development, can serve as the basic text for graduate-level courses in development, and has immediate implications for science and technology policy in the developing as well as the developed countries.

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Reference

[1] Paiva, Ruy Miller, "Modernizacão e Dualismo Tecnológico na Agricultura," *Pesquisa e Planejamento,* Vol. I, Dec. 1971.

Kay, David A., and Eugene B. Skolnikoff, eds., *World Eco-Crisis,* Madison, Univ. of Wisconsin Press, 1972, vii + 324 pp. ($2.50) Paper

The theme of this collection of thirteen essays, most of them by prominent figures in the environmental field, is given in the book's sub-title: "International Organizations In Response." Yet increasingly, observers of the environmental dialogue rightly wonder whether portents of doom do not take on the character of a repeated cry of wolf. "International Organizations"—for the most part, of course, the U. N.—in response to what? Merely to use the frightful term "eco-crisis" does not, in the absence of evidence on the nature and extent of man's threat to global ecological cycles, necessarily demonstrate the magnitude of the problem.

Following an introduction by Maurice Strong, two introductory essays—one on "Population, Resources and Technology" by Nagli Choucri and James Bennett, and the second on "The Time Dimension of Environmental Policy" by Dennis Meadows and Jorgen Randers—seek to furnish needed perspective. The empirical data in these articles are relatively sparse, at a high level of aggregation, and present few facts that will surprise a reader familiar with the literature of the field. Together, the essays reinforce existing widespread intuitive beliefs that the ecological problem has serious transnational and intergenerational dimensions, rather than establish any situation so widespread and imminently threatening as to justify the term "eco-crisis." It should be added, however, that the Meadows-Randers piece does furnish an elegant demonstration of an important (though oft-inspected) point: that time lags in processes of environmental degradation can often commit an ecosystem to irreversible deterioration before symptoms become sufficiently widespread to elicit needed changes in the known activities which drive the degradative sere.

After the introductory essays, the papers deal mostly with the broad outlines of institutionalized international programs in the environmental area. Though the emphasis perforce is on the United Nations and its instrumentalities, more-than-adequate and generally illuminating material is also presented on the roles of regional groupings such as O.E.C.D., international fiscal agencies such as the World Bank, and even the trade sector per se—the latter in a characteristically trenchant and hard-headed piece by two well-known analysts, Ralph D'Arge and Allen Kneese.

For potential readers of these institutionally-oriented articles, there is good news and bad news.

First, the good news. The essays doubtless represent a compendious presentation of the state of scholarship in the field. They bespeak intelligence and intellectual authority, but more than this, a sense of reflective understanding of a complex area. James A. Lee's discussion of "Environmental Considerations In Development Finance" will be found particularly illuminating in an important area, especially to the readers of a primarily political orientation to whom this collection seems to be directed. The prose in general is clear and pleasing, burdened with an absolute minimum of jargon. Because the categories in most of these presentations tend to run, in the main, in terms of organizations, broad trends, and jurisdictional lines, there is a sense of high abstractness to the book as a whole. But with this qualification mentioned, it remains that the writing is of a generally high caliber—concise, clear, communicative.

Now for the bad news. Much of the descriptive material—and the material is generally descriptive, rather than theoretical or analytical—reads like an organization chart presented in words rather than in pictures. But the impact is very much the same, a sense of surrealism or even irrelevance, at least to the degree that one doubts the ability of formal specification of authorities, jurisdictions or planned areas of activity to suggest how the world really does (or will) work. The "organizational chart" level of analysis particularly marks the pieces by Brian Johnson (on the United Nations post–Stockholm institutional response, a long wish-list of planned activities), Amasa Bishop and James Munro (on United Nations specialized agencies' roles), and Gordon MacDonald (a readable summary overview, pointedly keyed to the division of technical problem areas, entitled "International Institutions for Environmental Management").

Most notably absent are cost or even projected budget figures, let alone estimates of benefits likely to be gained for various levels of outlay. One is skeptical whether all the organizational charts and specifications of jurisdiction in the world will accomplish very much unless missions are converted into programs—and that means money, people, and power. This book suggests a large-scale response to what the title identifies as an absolutely crucial problem, but the prescriptions nevertheless remain general, hortatory, and almost entirely formal.

As a start, both as a work of scholarship and as an agenda for practical action, *World Eco-Crisis* is a useful work. But it is no more than the barest of starts when, on the authors' own showing, a great deal more than that is in order.

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Kneese, Allen V., and Blair T. Bower, eds., *Environmental Quality Analysis: Theory and Method in the Social Sciences,* Baltimore, The Johns Hopkins Press for Resources for the Future, Inc., 1972, ix + 408 pp. ($12.00)

This work contains a snapshot of 10 research projects, seven economic and three political science oriented, supported by Resources for the Future, in the area of environmental quality. Presented at a 1970 conference, the papers were discussed and revised for this publication; they display the high quality precedent established by RFF publications.

The book edited by Kneese and Bower is divided into three sections: "Environment and Economic Growth," "Developing Management Programs," and "Designing Political and Legal Institutions." The first two can be reorganized and classified into economic research on macro and micro approaches to environmental quality management.

The several macro papers include "Economic Growth and the Natural Environment" by d'Arge. He uses a general materials balance approach and does not include specific damage functions or alternative production processes, in part due to the extremely heavy computational load. The second macro paper, "A Materials-Process-Product Model" by Ayres, contains a stinging attack on models constructed without reference to the physical and chemical production processes. The data and computational requirements for implementation of his expanded materials balance model appear quite heavy. The third, by Russell and Spofford, includes the processes' specific aspects in the production model as well as an environmental diffusion model that accounts for residuals in the environment and a damages model relating quantities of diffused residuals to damages to final receptors. The damages, and in some respects the diffusion, model is limited to a quite esoteric development of an approach requiring substantial advances in knowledge before implementation. In spite of the significant differences in the papers, they agree that acceptable decisions in the environmental management area require a macro approach. The final macro paper evaluates the impact of public policy decisions, especially in the environmental quality area, on various income classes. It is the only consideration of the income distribution question, and it is a good beginning.

Papers dealing with micro economic problems include "Observation on the Economics of Irreplaceable Assets," which is outstanding. The model developed, the explanation of the underlying theory, the application to the Hells Canyon case, and the discussion of option value are all clearly and concisely done.

The other two micro oriented papers, concerning agricultural pesticides and air pollution damage, make significant progress toward the development of policy prescriptions. The authors utilize available information, which is recognized as less than optimal, rather simplistic quantitative techniques, and expert judgments in making tentative policy recommendations. While neither article provides sufficient information to satisfy the needs of the quantitative macro models presented in the book, they are solid contributions.

The remaining three papers concern political and legal institutions. Haefele does an outstanding job of indicating that often environmental institutions are not structured to reflect their constituency. The need for new and higher quality agencies is clearly demonstrated. Sax argues that we should expect and accept reliance upon the lawsuit by concerned individuals to assure the representation of the various interests. He cites several case examples where precedent changing judgments effectively balanced competing interests. The final paper is a chronological report of a research project identifying the leaders of the Northeastern Megalopolis. It implies that decisions are a function of the leaders' preferences, not of institutional format. These three papers, respectively, indicate that we need to develop better institutional frameworks, that the court system will perform "better" than formal institutions, and that personalities involved in leadership roles will dominate the institutional framework or the lack thereof in handling environmental quality problems.

In summary, the book may be an accurate reflection of the overall state of social science research in the environmental quality area. The individual papers represent the current state of model development in the several areas and should therefore be the subject of careful scrutiny by researchers with similar interests. But the whole of this book may be greater than the sum of the parts. That is, researchers and others will find it quite instructive and challenging to consider both the areas of agreement and the conflicts between and among the several papers. The appropriate level of aggregation is one of the questions implicitly raised by the book. Another is the extent of model detail necessary to achieve valid policy prescriptions versus the extremely serious problems of data availability and computational load. The question of appropriate public decision-making frameworks is only opened by the final three papers.

It is quite likely that an opportunity for considerable enlightenment was missed when the organizers of the conference from which these papers were taken did not get and report critical interaction among the authors. While sufficient progress in any direction has not been made to judge which is superior, a dialogue needs to begin if the research enterprise is to be reasonably efficient. However, at the same time we must heed Freeman's advice when he says "although there is a very large gap between what we need to know about the environment and what we do know, and this is a spur to further research, there is also a very large gap between what we already know about coping with environmental problems and what we are doing now. I think that closing this gap should be given our highest priority, that researchers have very important contributions to make to this effort and that these contributions should not necessarily be limited to doing more research" (p. 278).

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Lee, Teng-hui, *Intersectoral Capital Flows in the Economic Development of Taiwan, 1895–1960*, Ithaca, Cornell University Press, xx + 197 pp. ($10.00)

The direction of capital flow between the agricultural and the nonagricultural sectors has been a major unsolved issue in development economics. Since the appearance of Marx's thesis of the original capital accumulation, it has been an orthodoxy in socialist economic doctrine that surplus in agriculture may be mobilized as a major source of funds for industrial capital formation in the early stage of economic development. Stalin's policy of Soviet industrialization was along this doctrine. In more recent years, drawing primarily on the historical experience of Meiji Japan, a model has been suggested (by, among others, Bruce Johnston and Kazushi Ohkawa) that traditional peasant agriculture, prevalent in Asia, can increase output and productivity at a sufficiently rapid rate so that it can generate surplus or savings to be transferred for investment to the modern industrial sector. The contemporary relevance of this model has been seriously questioned by Shigeru Ishikawa and Vernon Ruttan. In their perspective the requirement for basic investment in irrigation and water control for increasing agricultural production at a speed compatible with the expansion of food demand due to explosive population growth in presently developing countries in Asia is so large that the possibility of resource outflow from agriculture is limited, and the direction of net resource flow may even be from agriculture to nonagriculture.

A solid empirical basis for this controversy is now provided by the comprehensive analysis of intersectoral capital flows in Taiwan by T. H. Lee. Following the sectoral social accounting framework developed by Ishikawa [1], Lee tried to measure the net capital flow between sectors as the balance of intersectoral commodity trade, which must be met by the sum of the balances of current financial transactions involving factor income payments and income transfers and of the capital account among sectors. In this sense, Lee's "capital flow" may be defined as "the flow of fund potentially usable for capital formation" (a part may be leaked out for consumption). In his two sector dichotomy, the *agricultural sector* includes both the agricultural production and the agricultural household sectors; all other sectors including government and foreign trade are classified in the *nonagricultural sector.*

The results of estimation indicate that the net real capital outflow from the agricultural to the nonagricultural sectors was recorded for the entire period from 1895–1960; its magnitude was significant, ranging from one-half to one-quarter of the total agricultural surplus—defined as the value of sale and transfer of agricultural products to nonagriculture. The net capital outflow in invisible form due to changes in the intersectoral terms of trade was relatively small for the prewar period, but its weight grew to occupy almost 50 percent for the postwar period. From the financial side of capital transfer the rent payment was dominant for the prewar period, and the weights of tax and the transfer of private saving through financial intermediaries increased for recent years.

Although Lee is very cautious in making any generalization of the Taiwan experience, implications of his analysis on the theory and policy for Asian development seem clear. Taiwan is similar to presently developing countries in South and Southeast Asia in two critical aspects. First, its initial conditions for modern agricultural growth in terms of the levels of agricultural productivity and of infrastructure for agricultural production, especially irrigation facilities, are comparable to those in Asian developing nations (Ch. 3). Second, Taiwan has experienced since the 1930's an explosive rate of population growth in the order of 2 to 3 percent per annum, and the population pressure has resulted in reduction in average cultivated land area per worker. In spite of such unfavorable conditions, agriculture in Taiwan achieved sustained growth in both total output and output per worker while saving the cost of conventional inputs per unit of output, thereby generating surplus to be transferred to the nonagricultural sector (Ch. 4). This experience of Taiwan suggests that traditional peasant agriculture in other Asian countries today is potentially capable of similar performance. The critical elements for this success are identified by the author as: "(a) the basic agricultural investment should be accompanied by technological improvement; (b) an appropriate investment scheme with large labor input and less input of capital goods should be selected; and (c) a capital transfer mechanism should be established" (p. 141).

This book is a monumental achievement in empirical research in recent years in terms of its most comprehensive and careful treatment of data based on a rigorous conceptual framework. An operationally meaningful model of economic development can only be built on the accumulation of research of this kind. It more than deserves the honor of the Ph.D. thesis award by the American Agricultural Economics Association (granted to the original manuscript in 1969).

The book could have been more valuable if the explanations of method and the data (Appendix A) were more detailed enabling the reader to follow the author's estimation procedures step by step. Also, more detailed explanations are desired on the advantages and limitations of the concept of "capital flow" and on the sector classification adopted by Lee in comparison with alternatives. For example, whether to classify resident landlords in the *nonagricultural sector* (as was done in this study) or not would greatly affect the results and the implications. Justification of the choice of 1935–1937 for the base years of the price indices should have been discussed since the direction and the magnitude of invisible capital flow are critically dependent on this choice. A major chapter that seems to be lacking would compare the results for Taiwan with other case studies, even though other studies are much less definitive than this study.

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Reference

[1] Ishikawa, Shigeru, *Economic Development in Asian Perspective*, Tokyo, Kinokuniya Bookstore, 1967.

Northrup, Herbert R., Richard L. Rowan, Darold T. Barnum, and John C. Howard, *Negro Employment in Southern Industry: A Study of Racial Policies in Five Industries, Vol. IV, Studies of Negro Employment*, Philadelphia, University of Pennsylvania Press, 1970, lvi + 710 pp. ($13.50)

This volume is fourth in a series of books designed to describe racial employment policies and industrial structures of American industries. The series covers the study of the racial policies of 30 American industries while the volume under review focuses on five traditionally southern-based industries. This effort represents funding by the Ford Foundation and professors in the Industrial Research Unit of the Wharton School of Finance and Commerce.

Few scholars have chosen to record the dimensions of racial employment patterns in the major industries of the South. Described is the employment status of blacks in the paper, lumber, tobacco, bituminous coal mining, and textile industries. Analysis of each industry concludes that the net result of unionism, affirmative action programs, and government policy has benefited relatively few blacks in these southern industries. Mechanization has displaced black workers in the unskilled category in each industry, and upgrading opportunities have been scarce for those reluctant to migrate. It was no surprise to find that black professionals were practically nonexistence in all of these industries while being grossly over-represented in the bottom blue collar occupations; correspondingly, a low proportion was found in the skilled craftsman and occupational group.

Blacks were assigned to the most unpleasant, difficult, dangerous, and terminal jobs; black employment usually thrived in proportion to the number of these types of jobs available. General penetration by blacks into skilled jobs has been more favorable where alternative employment opportunities were available for whites. It was comforting to find these facts so well documented in the manuscript. Due consideration is given to economic, social, historical, and institutional parameters of the black employment problems in these industries. Indeed, these were real impediments to the availability of entry level positions and upgrading the employment status of blacks in southern industries. Blacks still have a long way to go before they will overcome the perils of discrimination in these industries.

The authors provide an interesting analogy of the influence that these industries have on racial employment policies of new industries entering the southland. The general tendency has been for in-migrating companies to implement employment policies similar to these southern-based industries. A guarded confidence is expressed for the continuation of the unprecedented breakthroughs of the last decade.

The scope of the entire series of studies makes it difficult to be critical of broad sins of omissions. However, one glaring omission is study of the plight of black workers in the restaurant industry and domestic service. This would give a more complete picture of black employment problems in the South. Another useful addendum to the reports would be the blacks' conception of discrimination in all these industries and the extent to which they are knowledgeable of institutional remedies. Despite the minor problems cited, the authors have made a major contribution to documenting the plight of blacks in these southern industries. Surely the time is right for appreciating the foresight of the authors in making this manuscript available.

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Papandreou, Andreas G., *Paternalistic Capitalism*, Minneapolis, University of Minnesota Press, 1972, ix + 190 pp. ($7.50)

Robinson, Joan, *Economic Heresies*, New York, Basic Books, 1971, xix + 150 pp. ($6.95)

Depreciation of economic orthodoxy is in vogue. A score of authors have lately rivaled in accounting for discrepancies between received economic theory and unsalubrious events of our time. Five notable Americans did a good pasting in the January 22, 1972 *Saturday Review*. A dozen papers at the 1971 annual meeting of the fledgling Association for Evolutionary Economics dealt with the subject [1].

Few critics are more distinguished, and none more articulate, than Andreas Papandreou and Joan Robinson. In their recent books Papandreou wields a sharp axe and Robinson a deft scalpel. The two begin in parallel fashion. Both name the Depression as the first instance of bankruptcy of economic theory. They turn quickly to the despairs of our day. Papandreou declares that "economists' faith in the thermostatic role of central government" is shaken by unemployment-with-inflation, persistent depressed areas, and manifest faults in resource allocation (pp. 10–11). Robinson cites "the persistence of poverty —even hunger—in the wealthiest nations, the decay of cities, the pollution of environment, the manipulation of demand by salesmanship, the vested interests in war . . ." (p. xv).[1]

In their allegations of error in theory both authors identify school-of-thought targets. Papandreou even personalizes his with rank order. His secondary quarries are the team of Paul Baran and Paul Sweezy as spokesmen for neoMarxism, and John Kenneth Galbraith and his technocratic view. Baran and Sweezy are applauded for several insights but deplored for making "Keynes . . . the theorist par excellence . . ." (p. 62). Galbraith is chided as "apologist . . . [for a] more or less idealized, benign, and optimistic version of the actual state of affairs" (p. 65). Yet from Galbraith's thesis on eclipse of consumer sovereignty comes Papandreou's book title.

Papandreou's select adversary is Robert Dorfman, janissary for what he calls mainline orthodox economists and, when he deplores their distorted concepts of the state, nominalists.

Joan Robinson zeroes in on about the same group, but she calls them the neo-neoclassics and their dogma the new orthodoxy. Though not so personal in her refutations, she cites Ferguson for the clarity of his misconstructions.

In contrast with Papandreou, Robinson is respectful to the memory of Keynes. Nevertheless, she grants that "he did not distinguish between profitable investment and socially beneficial investment" (p. x). Had he lived longer he might have done better. Irrespective of that, there is no excuse for neo–neoclassics' moving backward as they accept the nefarious notion that "what is profitable is right."

Papandreou does not tarry in censuring contemporary theory: to characterize the modern industrial economy as market capitalism is a "myth," for the term fits only an "ideal society of shopkeepers"; economic efficiency is subordinate to initial distribution of wealth; orthodox theory fits administrative statics but not creative dynamics; externalities and public goods are unaccommodated phenomena.

The astute Robinson would hardly disagree but develops a more sophisticated argument. Skipping few topics in theory, she probes interest and profits, nonmonetary models, prices and money, theory of the firm, growth models. To distill the essence of her viewpoint is hazardous, but it can be summed in terms of: influence of time, ambiguousness of definition of factors of production and particularly capital, and errors in perceiving various decision patterns in the modern business firm. The first two are specified in the text; the third is inferred.

In the modern monetary economy many current values are based on anticipation, a familiar axiom; yet the neo-neoclassics commit errors as they "attempt to escape from time" (p. 61) and, confused by dynamics and comparative statics, fail "to distinguish between coexisting differences and sequential change" (p. 142).

The neo-neoclassics, says Robinson, cannot avoid the capital trap: capital as equipment, capital as wealth, capital as finance. As to rate of profit, they still cannot tell us "how it comes to be what it is" (p. 34).

Why are so many economic models faulty? Robinson implies that theorists are forever reading in a behavior paradigm that is empirically invalid and that they snub their noses at institutional considerations, and, moreover, may be subliminally motivated ideologically.

With these implications she joins forces once more with the less scholarly Papandreou. Robinson: "'Pure theorists' sometimes take a supercilious attitude to 'structuralists' or 'institutionalists.' They prefer a theory . . . uncontaminated with any material content" (p. 142). Papandreou: The influential "behavior of the large corporation . . . is a direct consequence of the structure, the institution, and the overall value system of the contemporary capitalist society . . ." (p. 69).

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[1] In her Richard T. Ely lecture to the American Economics Association, for which she drew on the book reviewed here, Robinson named the Depression and contemporary failures as occasioning, successively, the first and second crises in economic theory. "The first crisis arose from the breakdown of a theory which could not account for the *level* of employment. The second crisis arises from a theory that cannot account for the *content* of employment" [2, p. 6].

Papandreou extends his exposition into lengthy discourses on political matters and processes. He comments on "the apex of the pyramid of power" as being occupied by the corporate managerial-capitalist elite" (p. 115). But recently the military man has elbowed his way in and subordinated the politician. International mercantilism "is one of the essential attributes of paternalistic capitalism" (p. 143). Vintage observations are critical of United States world posture, such as taunting Secretary of State Byrnes' 1945 rebuke to the Russians for rigging the Bulgarian elections, just after the second United States atomic bomb pulverized Nagasaki; and berating President Truman's commitment to repel Soviet Communism in Greece when Stalin himself saw the Greek guerrillas as a threatening nuisance. Such notes are interesting in view of Papandreou's identification with the pre-Colonels Greek government.

Robinson toys with political bias as explanation of economists' faulty expositions. She especially notes their apologetics for rentier income, e.g., ". . . the moral justification for rentier income that Marshall sought to derive . . ." (p. 14); "Keynes rather lost his grip on the distinction between the rentier and the entrepreneur" (p. 31); and in Keynes' "utopian vision of a future . . . the euthanasia of the rentier will have removed the worst vices of capitalism . . ." (p. 80).

Powerful though its message, and more technically convincing than Papandreou's, Robinson's treatise is never shrill, by no means iconoclastic. Both books give voice to the dilemma of all economic constructions. The economic universe is complicated beyond human comprehension. Therefore economic theory is always an exercise in abstraction. How well chosen is anyone's model? The problem does not lie in achieving internal consistency; economists manage *that* very well. It is rather in being sure the simple model reflects complex reality accurately enough. Perhaps all published models should carry a label like a cigarette warning: this abstraction may be dangerous to your economic understanding.

To sum this review, *Paternalistic Capitalism* is engaging but not uniquely enlightening; *Economic Heresies* is hard to read but worth it. Both take us back to the query asked by Papandreou's pre-Christian ancestors: in economics as in philosophy, what, indeed, is truth?

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References

[1] *J. of Econ. Issues* 6:1 ff., March 1972, various papers.
[2] ROBINSON, JOAN, "The Second Crisis of Economic Theory," *Am. Econ. Rev.* 62:1-10, May 1972.

Rothblatt, Donald N., *Regional Planning: The Appalachian Experience*, Lexington, D.C. Heath and Co., 1971, xvii + 281 pp. ($15.00)

From the beginning the federal government has been concerned with facilitating the economic development of various regions of the nation. Policy and programs dealing with land, water, railroads, highways, national defense, agriculture, and many other topics have responded to this concern. Perhaps it is more accurate to say the response has been to the concerns of the various regions.

A difference in recent years has been the use of new regional institutional arrangements to implement regional economic development programs. The most significant is the Appalachian Regional Commission that has employed a political base and procedures of program development that should have great appeal. Donald Rothblatt justifies his study of the ARC in these terms. By linking regional planning to the governors in a way that provides substantial rewards for their participation, planning is given a relevance it usually lacks.

Rothblatt nicely summarizes the history of the Commission. He notes that two widespread occurrences of flooding provided much of the impetus for the governors to join together, but not just to secure the usual federal largess for flood control. Indeed, water projects were put off as a focus for political action by giving the federal water agencies the time-consuming task of developing a separate water plan. Rather the governors seem to have seen a bigger opportunity—the chance to obtain and control massive funding to help the depressed parts of their respective states. Rothblatt sees this as the maturation of a regional consciousness. Whether it was a new sense of region or a new sense that together they could have access to the federal treasury more effectively than separately, a focus on highways (60 percent of the funds) was the result. A poor region with 9.1 percent of the population was now able to attract 9.7 percent of federal grants.

Rothblatt is impressed, and he should be, by the two-stage decision model imbedded in the legislation and the procedures of the Commission. A regional income efficiency goal was expressed as the concentration of public investments in urban areas that had somewhat greater potential for future growth. This in turn was subject to a state-expressed sense of needs. While the highway program deviated from the regional goal from the start, the other grants were increasingly influenced by sophisticated planning. Perhaps because the wish induced the thought, Rothblatt sees the procedures of ARC converging upon an approximation of a rational decision model.

Based upon concepts of benefit-cost analysis, Rothblaft develops a two-stage analytical model that has some novel features. He then reviews the decisions that were made, noting that while little benefit-cost analysis was actually done, substitute criteria were employed to much the same end. He concludes that his two-stage model could have been implemented but was not. State goals were not articulated for the first two years in terms precise enough for quantitative analysis. But more to the point, the governors did not want to be constrained by technical criteria. A major weakness of the study is that the reasons for this reluctance to be encumbered by rational criteria are not as carefully examined as are many other aspects of the Appalachian experience.

Much is made of the expression of a regional economic efficiency goal by concentration in growth centers. The states designated the growth centers and by the end of FY 68, 95 percent of the dollars for nonhighway grants went to these centers. With the implementation of one man, one vote and flexible definitions of a growth center, this allocation rule could still represent little real constraint on a politically relevant allocation mechanism.

Rothblatt sees two major ways to improve the results of ARC and seems to suggest that they be incorporated into the emulation of ARC being considered in many other parts of the nation. First, something like this benefit-cost analysis model should be employed to increase the efficiency of the investments made. Second, local groups and governments should have greater control and participation. But what he does not make clear is whether the program could survive those changes.

Greater local participation might well increase the pressure to move away from rational criteria. Rothblatt also laments the fact that projects are chosen only between those locally initiated now, rather than reflecting a rational identification of local needs. Needs instead are expressed by the governors and appear based on intuitive rather than analytical grounds. Benefit-cost analysis has long been used to explain why a local request had to be denied, or to justify granting it, letting other considerations remain unstated. The growth center concept serves much the same function. Perhaps greater local participation with concurrent increase in the use of such tools would produce more efficient results, especially if in the process analytically determined needs were translated into more effective locally initiated project proposals.

But more to the point is the risk of reducing the rewards for participation by the governors. The professional's preference for greater reliance on his analytics sometimes blinds him to the fact that decision makers obtain and keep the ability to make decisions by building power. Governors, congressmen, presidents and agency heads compete for support. Federal and state agencies see regional groups such as ARC primarily as competitors for the same clients. A regional agency that depends upon governors for survival has to build governor power or obtain a comparable substitute.

The reader will find this study to be a useful examination of one recent manifestation of regionalism. But to put ARC into perspective he would do well to go further, such as a recent report by the Advisory Commission on Intergovernmental Relations entitled *Multistate Regionalism* (April 1972, Report A-39, U.S. Government Printing Office, $2.00). Here the coordination of the ARC with competing federal programs is found to be less than complete. This study also reviews the first generation of spinoffs from ARC, the Title V regional commission, and notes the lack of participation by the governors and the results in terms of competitiveness with other programs. Interstate compacts and basin planning groups, proposed commissions for land-use planning, transportation, and coastal zone management as well as Nixon's federal regional councils are also examined. The recommendations are mild and represent division of opinions on where the nation should go with such devices. But only the Appalachian Regional Commission has developed a significant power base and with it a significant budget. This fact should not be lost by its students and its emulators.

We would do well to study such devices as means to generate support and cut the costs of getting agreement. Efficiency in coalition building, bargaining across a wide range of values, reducing conflict and resulting inaction, and the like may have more to do with achieving social efficiency than the application of sound project evaluation methodology. Rothblatt makes an attempt to get past project evaluation analytics and should be praised for the attempt even though he did not get quite as far as this reviewer would have liked.

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Schultz, Theodore W., *Investment in Human Capital*, New York, The Free Press, 1971, xii + 272 pp. ($8.75)

Schultz in *Investment in Human Capital* has combined writings from his earlier path-breaking research on human capital with his more recent thoughts on its implications as a guide to the allocation of resources in education and research. He begins by arguing that to understand economic modernization, a comprehensive view of capital is needed in which education and research are forms of capital. The need to bring technical change into the body of economic theory by accounting for the heterogeneity of capital is stressed. Investment can improve the abilities of man as well as the soil. New techniques require investment and become types of capital in this formulation. Scientific research and education are "industries" turning out new capital which is more efficient than the old.

Schultz advances three hypotheses: when human capital is included, the ratio of capital to income has been constant; differences in earned income are primarily the result of different human investments; and investment in human capital is increasing the equality in the distribution of personal income. These are extremely important hypotheses which we will return to later.

He then looks at studies of the cost of education and the capital stock of education in preparation for a discussion of allocating resources to education according to their rate-of-return. He concludes that the rate-of-return is most useful as an indicator leading to efficient allocation although the available estimates of factor costs and social rates-of-return are far from satisfactory.

Schultz next turns to the allocation of resources to research. He says research has two economic roles; it is transformed into new skills or into new materials. He feels that economic studies to clarify the return on research are feasible and represent a priority area of analysis.

In the final section he calls for an approach to economic research that includes institutions as variables which respond to the dynamics of economic growth. He claims that once agriculture achieves a growth momentum, the farmers will demand institutional change.

Human capital has had a profound influence on economic theory and practice over the past decade. Schultz has been one of the major forces behind this influence and an eloquent spokesman for the study of investment in man. This book continues in that tradition.

It was disappointing, however, to find no mention of several recent criticisms of human capital theory as presently formulated. The critics raise important questions which appear to limit the usefulness of human capital theory as a guide to resource allocation until they are resolved. For example, Gintis [1] has shown that we know very little about the mechanism through which education affects productivity or earnings. His work indicated that the function of schools most related to worker productivity and earnings was the imparting of personality traits and attitudes conducive to job performance rather than cognitive development. If true, rate-of-return calculations have little substantive meaning since little is known about the relationship between the cost of a year's schooling and the effectiveness of schools in socializing their students. This implies that while Schultz' second hypothesis may be true, the more interesting question is why. The question of how education affects productivity and earnings should be given high priority in future research.

As a second example, Thurow has raised another problem with rate-of-return to education calculations. He notes that if the labor market is characterized by job competition rather than wage competition, "neither marginal nor average income gaps between high school and college laborers serve to estimate the gains from more education either to the individual or to society" [2, p. 32]. Thurow concludes the job competition is prevalent in the labor market and questions Schultz' third hypothesis. This is another question on which evidence must be gathered before much faith can be placed in using the rate-of-return to allocate resources to education.

In summary, this is a very readable and occasionally stimulating book, especially the treatment of research and institutions. However, human capital theory has more gaps to be filled than are indicated in this book before it should be taken too seriously by policymakers. Although it is primarily written for the noneconomist interested in the allocation of education and research, it is an excellent introduction to developments in human capital theory for economists not familiar with the literature in this area. Agricultural economists will appreciate the wealth of examples he pulls from the agricultural sector.

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References

[1] GINTIS, HERBERT, "Education, Technology, and the Characteristics of Worker Productivity," *Am. Econ. Rev.* 61:266–279, May 1971.

[2] THUROW, LESTER C., AND ROBERT LUCAS, "The American Distribution of Income: A Structural Problem," Joint Economic Committee, 92nd Congress, 2nd Sess., Government Printing Office, Washington, D.C., 1972.

Webber, Michael J., *Impact of Uncertainty on Location*, Cambridge, The M.I.T. Press, 1972, xviii + 310 pp. ($12.95)

To fully explain why economic activity is unevenly distributed over space, it is necessary to consider the impact of uncertainty on firm decisions. That is the central theme of this book, and it is one that interests many readers of this *Journal*. Webber does not claim to offer a fully integrated theory of how uncertainty should be treated, but has set out "to supply a preliminary account of one direction in which new location theory may profitably evolve" (ix). The first part of the book deals with location patterns under certainty (Chapters 2–4) and the second part with location patterns when entrepreneurs are uncertain (Chapters 5–9). The term *uncertainty* as used by Webber refers to decision making under conditions of less than perfect knowledge.

Webber examines the effects of uncertainty which arise from three sources: the behavior of rivals, the state of the environment, and changing techniques of production. Uncertainty concerning the location decisions of rivals is found to encourage firms to locate within towns. Such behavior can be reproduced using game-like models for linear and bounded markets (Chapters 6 and 7). Comparing these location decisions with those of firms in certainty models, Webber concludes that place sizes result which are larger than optimal. As one possible remedy, he suggests land use planning under which particular sites are allocated to particular uses (p. 281).

Uncertainty concerning the state of the environment is shown to influence a firm's production decisions. Costs and returns vary over space in a nonuniform manner in response to price and yield variations, to changes in the growth rate of the economy, innovations and changes in fashion, and other stochastic elements. While it is difficult to generalize about yield variability and space, numerous investigations support the notion that such variability does influence production decisions. With respect to price variability, Webber illustrates his conclusion that the more distant a firm locates from its market, the larger the variability in prices and, therefore, the greater the uncertainty of returns. He shows how the location of production over space is influenced by these forces through the allocation of inputs among competing enterprises, the scale of output selected by the firm, and through factor costs (Chapter 8). While some information concerning the probable future state of the economy might be provided by a planning authority, the author holds that it is quite unlikely that this source of uncertainty can be overcome. Some improvement in production decisions might be possible through an insurance scheme, although such potential improvements should be weighed against expected costs of the program.

Lags in the adoption of new techniques of production are found to result in social inefficiencies. "These inefficiencies are due, firstly, to the fact that entrepreneurs do not adopt innovations quickly and, secondly, to the fact that learning processes may imply sub-optimal locational equilibria" (280). He suggests that more rapid diffusion might result from mass media advertising and by paying individual entrepreneurs to advocate the innovation to others. Including location factors in a diffusion model leads Webber to the conclusion that "the rate at which innovations are adopted profitably increases with the size of the city or region. Once the population in a system is unevenly distributed over the system, innovation production and diffusion tend to increase that degree of concentration of activity" (262).

Formulation of location models which explicitly consider the effects of uncertainty is shown to be important and some interesting leads are suggested. However, as "an up-to-date survey of location analysis" (vii) with seventeen pages of references, it is surprising that Webber cites only two articles in the *American Journal of Agricultural Economics*, a single publication of the U. S. Department of Agriculture (dated 1918), and not a single agricultural experiment station bulletin or monograph. This hardly seems adequate coverage of the work of the profession relating to location theory and its application to the real world. One is led to the conclusion that our diffusion efforts might well be directed to a wider audience than has been the case in the past.

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Zwick, David, and Marcy Benstock, eds., *Water Wasteland: Ralph Nader's Study Group Report on Water Pollution*, New York, Grossman Publishers, Inc., 1971, xvii + 494 pp. ($7.95)

One cannot but admire the energy and enthusiasm that went into the production of this large book. With two authors, aided by two consultants (John C. Esposito and Ralph Nader), 14 undergraduate members of the task force, 8 special projects helpers, two production directors, and two research assistants, the book, begun in the summer of 1969, was "put to bed" in March 1971. This would be a formidable time-table for seasoned scholars in the water pollution field. One would have thought it impossible for amateurs; and, in fact, it was.

The book reads like an unedited collection of seminar papers in Poly Sci 300: Politics of Pollution. As in such a collection, there are good spots and bad spots and, mostly, indifferent spots. I shall address these in order.

Good Spots: Parts One and Two, "Polluters and Protectors," pp. 3–115. This is a concisely written and informative overview of the water pollution problem: facts, politics, and attitudes are nicely intertwined into a balanced yet forceful presentation. Agricultural economists will find Chapter 5 especially interesting. Here are discussed pollution from agriculture, land development, and the mining industry. As the authors note in their chapter heading, these industries tend to be "non-point" sources of pollution. A Rutgers study, for example, found that only one-quarter to one-third of the water pollutants in certain New Jersey basins could be traced to their origin. The researchers were quite rightly "stupified."

Agriculturists "are far and away ***the worst polluters in the entire nation.***" Agricultural livestock wastes amount to some 1.7 billion tons annually and the problem compounds as "Old MacDonald" puts those animals in concentrated feedlots. The average steer excretes the waste of 16.4 humans. Volatile ammonia from urine evaporates and is reabsorbed into surface water. The BOD of feedlot waste is 5–100 times that of municipal sewage. In the words of one official, "Something which looks good at one end may be pretty bad at the other."

And so it is with this book. From the high point of these first two parts, the book steadily decays—with a half-life it seems, as one wades on, of several centuries—occasionally dipping into negative values.

An example of the latter is what has apparently become *de rigueur* in productions of this kind: the apparent theft and subsequent publication of private correspondence. In this particular case, a memo from the Director of Public Relations of the Reserve Mining Company in Minnesota to the president of that company was filched and published. The memo concerns a forthcoming trip of Stewart Udall, then Secretary of the Interior, to have a look at Reserve Mining's pollution of Lake Superior. The interesting thing about this memo is that it is so innocuous. Other than the fact that the company was tipped off in advance of the Secretary's visit, there is absolutely nothing scandalous about it at all. Indeed, the company comes out looking rather better than one would have expected. Certainly, there is nothing in the memo as disgraceful as theft and publication of other people's correspondence. This combined with the self-righteous moralizing of the authors makes a very sorry episode.

Most of the rest of the book is written in a similar vein. Testimony from the *Congressional Record* is printed and examined to the point of exhaustion. The *intent* is clearly to leave the reader feeling that evil Business and inept Bureaucracy have effectively emasculated the water pollution Laws. In fact, the country has made enormous progress in this field—far more than I, for one, would have thought possible.

In sum, these most unacademic authors have fallen into the old academic trap of believing the fatter the work the heavier the message. Had they taken Parts One and Two and added seventy-five pages of the remaining three-hundred, they would have had a good book.

DAVID SECKLER
Colorado State University

Books for listing in this section should be sent to the Book Review Editor (see inside front cover for address).

Books Received

Aaron, Henry J., *Shelter and Subsidies: Who Benefits from Federal Housing Policies?*, Washington, D.C., The Brookings Institution, 1972, xiv + 238 pp. $7.95.

Amerine, M. A., H. W. Berg, and W. V. Cruess, *The Technology of Wine Making,* 3rd ed., Westport, The AVI Publishing Company, Inc., 1972, ix + 802 pp. $27.00.

Barlowe, Raleigh, *Land Resource Economics: The Economics of Real Property,* 2nd ed., Englewood Cliffs, Prentice-Hall, Inc., 1972, viii + 616 pp. $13.95.

Bartz, Patricia M., *South Korea,* New York, Oxford University Press, 1972, xiii + 203 pp. $18.75.

Boulding, Kenneth E., and Tapan Mukerjee, eds., *Economic Imperialism: A Book of Readings,* Ann Arbor, The University of Michigan Press, 1972, xviii + 338 pp. $3.95. Paper.

Breit, William, and Harold M. Hochman, eds., *Readings in Microeconomics,* 2nd ed., New York, Holt, Rinehart and Winston, Inc., 1971, xv + 570 pp. Price unknown.

Brown, H. James, J. Royce Ginn, Franklin J. James, John F. Kain, and Mahlon R. Straszheim, *Empirical Models of Urban Land Use: Suggestions on Research Objectives and Organization,* New York, National Bureau of Economic Research, 1972, xvi + 100 pp. $5.00.

Cagan, Phillip, Marten Estey, William Fellner, Charles E. McLure, Jr., and Thomas Gale Moore, *Economic Policy and Inflation in the Sixties,* Washington, D.C., American Enterprise Institute for Public Policy Research, 1972, v + 267 pp. $4.50.

Collinson, M. P., *Farm Management in Peasant Agriculture: A Handbook for Rural Development Planning in Africa,* New York, Praeger Publishers, 1972, xxvi + 444 pp. $22.50.

Cummings, Ronald G., *Water Resource Management in Northern Mexico,* Baltimore, The Johns Hopkins University Press for Resources for the Future, Inc., 1972, xii + 68 pp. $3.50. Paper.

Finberg, H. P. R., ed., *The Agrarian History of England and Wales, A.D. 43–1042,* Vol. 1, Part 2, New York, Cambridge University Press, 1972, xviii + 566 pp. $37.50.

Fukutake, Tadashi, *Japanese Rural Society,* Ithaca, Cornell University Press, 1972, xiv + 230 pp. $2.95.

Gittinger, J. Price, *Economic Analysis of Agricultural Projects,* Baltimore, The Johns Hopkins University Press, 1972, viii + 221 pp. $10.00.

Hailstones, Thomas J., *Basic Economics,* 4th ed., Cincinnati, South-Western Publishing Co., 1972, xv + 654 pp. Price unknown.

Heller, Alfred, ed., *The California Tomorrow Plan,* Los Altos, William Kaufmann, Inc., 1972, 120 pp. $7.95.

Hite, James C., and Eugene A. Laurent, *Environmental Planning: An Economic Analysis, Applications for the Coastal Zone,* New York, Praeger Publishers, 1972, xiv + 155 pp. $13.50.

Houck, James P., Mary E. Ryan, and Abraham Subotnik, *Soybeans and Their Products: Markets, Models, and Policy,* Minneapolis, University of Minnesota Press, 1972, ix + 284 pp. $10.00.

Hutchins, Wells A., *Water Rights Laws in the Nineteen Western States,* Vol. I, Washington, D.C., United States Department of Agriculture, 1971, xxx + 650 pp. $4.00.

Hutchinson, Joseph (Sir), *Farming and Food Supply: The Interdependence of Countryside and Town,* New York, Cambridge University Press, 1972, x + 146 pp. $11.00.

Imel, Blake, Michael R. Behr, and Peter G. Helmberger, *Market Structure and Performance: The U.S. Food Processing Industries,* Lexington, D. C. Heath and Company, 1972, xv + 115 pp. $10.00.

The International Bank for Reconstruction and Development, *World Bank Operations: Sectoral Programs and Policies,* Baltimore, The Johns Hopkins University Press, 1972, xiii + 513 pp. $12.50.

Ironmonger, D. S., *New Commodities and Consumer Behavior,* New York, Cambridge University Press, 1972, xviii + 200 pp. $19.50.

Johnson, Glenn L., and C. Leroy Quance, eds., *The Overproduction Trap in U.S. Agriculture: A Study of Resource Allocation From World War I to the Late 1960's,* Baltimore, The Johns Hopkins University Press for Resources for the Future, Inc., 1972, xvii + 211 pp. $10.00.

Kao, Charles H. C., *Brain Drain: A Case Study of China,* Taipei, Mei Ya Publications, Inc., 1971, xiii + 187 pp. $5.00. Paper.

Kepner, R. A., Roy Bainer, and E. L. Barger, *Principles of Farm Machinery,* 2nd ed., Westport, The AVI Publishing Company, Inc., 1972, xi + 486 pp. Price unknown.

Larkin, John A., *The Pampangans: Colonial Society In A Philippine Province,* Berkeley, University of California Press, 1972, xvii + 340 pp. $13.50.

Machlup, Fritz, Armin Gutowski, and Friedrich A. Lutz, *International Monetary Problems,* Washington, D.C., American Enterprise Institute for Public Policy Research, 1972, 136 pp. $8.50.

McCoy, John H., *Livestock and Meat Marketing,* Westport, The AVI Publishing Company, Inc., 1972, ix + 465 pp. $21.00.

North, Mack O., *Commercial Chicken Production Manual,* Westport, The AVI Publishing Company, Inc., 1972, viii + 645 pp. $30.00.

Owen, John D., *The Price of Leisure,* Montreal, McGill-Queen's University Press, 1970, x + 169 pp. $9.00.

Pauly, Mark V., *Medical Care at Public Expense: A Study In Applied Welfare Economics,* 2nd ed., New York, Praeger Publishers, 1971, xvi + 160 pp. $13.50.

Plowden, David, *Floor of the Sky: The Great Plains,* New York, Sierra Club Books, 1972, 128 pp. $19.75.

Poats, Rutherford M., *Technology for Developing Nations: New Directions for U.S. Technical Assistance,* Washington, D.C., The Brookings Institution, 1972, xiii + 255 pp. $7.50.

Potholm, Christian P., and Richard Dale, eds., *Southern Africa in Perspective: Essays in Regional Politics,* New York, The Free Press, 1972, xiii + 418 pp. Price unknown.

Pryde, Philip R., *Conservation in the Soviet Union,* New York, Cambridge University Press, 1972, xv + 301 pp. $12.50.

Ranney, David C., *Water Quality Management: An Analysis of Institutional Patterns,* Madison, The University of Wisconsin Press, 1972, xii + 158 pp. $7.50.

Rossi, Peter H., and Walter Williams, eds., *Evaluating Social Programs: Theory, Practice, and Politics,* New York, Seminar Press, Inc., 1972, xviii + 326 pp. $10.95.

Sarkar, Goutam K., *The World Tea Economy,* New York, Oxford University Press, 1972, xviii + 237 pp. $5.00.

Schneidau, Robert E., and Lawrence A. Duewer, eds., *Symposium: Vertical Coordination in the Pork Industry,* Westport, The AVI Publishing Company, Inc., 1972, x + 277 pp. $19.50.

Schultze, Charles L., Edward R. Fried, Alice M. Rivlin, and Nancy H. Teeters, *Setting National Priorities: The 1973 Budget,* Washington, D.C., The Brookings Institution, 1972, xx + 468 pp. $3.50.

Spring, Joel H., *Education and the Rise of the Corporate State,* Boston, Beacon Press, 1972, xiv + 206 pp. $7.95.

Stuart, Robert C., *The Collective Farm in Soviet Agriculture,* Lexington, D. C. Heath and Company, 1972, xx + 254 pp. Price unknown.

Telser, Lester G., *Competition, Collusion, and Game Theory,* Chicago, Aldine · Atherton, Inc., 1972, xix + 380 pp. $12.95.

Tewari, R. N., *Agricultural Planning and Co-operatives,* Delhi, Sultan Chand & Sons, 1972, viii + 100 pp. $3.50.

Thomas, D. Woods, Harry R. Potter, William L. Miller, and Adrian F. Aveni, eds., *Institution Building: A Model for Applied Social Change,* Cambridge, Schenkman Publishing Company, 1972, vii + 291 pp. $8.95.

Tintner, Gerhard, and Jati K. Sengupta, *Stochastic Economics: Stochastic Processes, Control, and Programming,* New York, Academic Press, 1972, xi + 315 pp. $16.00.

Weldon, Roger J., and Alan B. Humphrey, *Anova 45: A Flexible Computer Program For the Analysis of Variance,* Tucson, The University of Arizona Press, 1972, ix + 69 pp. $6.95. Paper.

Wellford, Harrison, *Sowing The Wind,* New York, Grossman Publishers, Inc., 1972, xxiii + 384 pp. $7.95.

Announcements

1973 ANNUAL AAEA MEETING

The 1973 Annual AAEA Meeting will be held August 8–11 at the University of Alberta, Edmonton, Alberta. The dates fall on Wednesday, Thursday, Friday, and Saturday, rather than Sunday, Monday, Tuesday, and Wednesday, which has been the pattern for many years.

Dr. Travis Manning, as Head of the Department of Agricultural Economics at the host institution, is in charge of local arrangements. It is suggested that requests for space or other needs prior to, during, or subsequent to the meetings be sent to Dr. Manning.

The meeting will be held jointly with the Canadian Agricultural Economics Society and the Western Agricultural Economics Association. The theme will be the following: **The North American Continent: Its Agriculture and Commerce, Its Natural and Human Resources, and Its Institutions.**

The program format will be similar to that of the past three years. Some change in timing of the various events will be made, however. The Awards Program will be held Thursday evening. Therefore the undergraduate student contests will need to begin on Wednesday.

Dr. David Boyne, Ohio State University, will serve as coordinator of the contributed paper sections. He will announce ground rules for the contributed papers in the near future.

Papers presented at the general session, sectional meetings, and major seminar papers will be published in the 1973 Proceedings issue (December 1973 AJAE). Papers in subseminars, contributed papers, and discussions will be presented by title and author only in the Proceedings issue. Such papers may, of course, be submitted to the AJAE for standard editorial review and possible publication.

More detailed information on the program will be released soon in the form of a presidential newsletter.

UNDERGRADUATE DEBATE, PUBLIC SPEAKING, AND ESSAY COMPETITIONS

Competition is open to any undergraduate student interested in agricultural economics. Participants are encouraged to become members of chartered student-section affiliates of the American Agricultural Economics Association, but such membership is not required to enter the various contests. No individual student may enter both the debate and the public speaking competitions in the same year.

Public Speaking Competition

The public speaking may be on any topic in the area of agricultural economics. Each speech will be limited to 10 minutes' duration.

Chartered chapters or individuals must declare their intention of participating in the public speaking competition by writing *no later than June 1, 1973,* to Dr. Donald J. Epp, Chairman, AAEA Student Activities Committee, Weaver Building, The Pennsylvania State University, University Park, Pennsylvania 16802.

Debate Competition

The topic to be debated in 1973 will be announced directly to all the departments.

A declaration of intention to participate in the debate competition must be made in writing *no later than June 1, 1973,* at the address given above. Names of the contestants and/or alternatives and coaches, along with the mailing address of each, should be included. No more than one debate team from one school may participate in the debate contest.

Student Essay Contest

The essay contest does not require attendance at the AAEA's annual summer meeting. It was developed primarily for students who find it impossible to attend the annual meeting and for students whose abilities and interest tend to be in research and/or writing. The development and preparation of a manuscript for purposes of publication is one of the objectives of this contest. Essays may deal with any topic in agricultural economics, agricultural industries, or rural sociology. The 1973 award paper will be published in the 1973 Proceedings issue.

Manuscripts should not exceed 2,500 words in length and should be prepared according to the instructions appearing on the inside back cover of the *American Journal of Agricultural Economics.* Manuscripts must be submitted in *triplicate* by *June 1, 1973,* to Dr. Donald J. Epp, Weaver Building, The Pennsylvania State University, University Park, Pennsylvania 16802.

SOUTHERN AGRICULTURAL ECONOMICS ASSOCIATION

Atlanta, Georgia, is the site of the 1973 annual meeting of the Southern Agricultural Economics Association scheduled for Feb. 5–7, 1973. Main topics of the meetings are commercial agriculture, rural development and planning, and emerging issues in agricultural economics.

Regular membership in the SAEA is $6.00 per year, and junior membership (students) is $3.00 per year. To obtain further information or to enroll, write to Luther Keller, Secretary-Treasurer of SAEA, Department of Agricultural Economics, The University of Tennessee, P.O. Box 1071, Knoxville, Tennessee 37901. Make checks payable to the Southern Agricultural Economics Association.

LATIN AMERICAN TEACHING FELLOWSHIPS

The Latin American Teaching Fellowships program is now accepting applications for positions in Latin America from individuals in the social and natural sciences, engineering, business, law, and medicine who hold Ph.D.'s, professional degrees, or are Ph.D. candidates. Placement possibilities exist for the 1973–74 academic year. These opportunities are part of a service program designed to assist Latin American universities to develop more advanced programs. Salaries are thus geared to moderate subsistence level rather than being competitive with North American salaries. Inquiries should be addressed to Latin American Teaching Fellowships, Fletcher School of Law and Diplomacy, Tufts University, Medford, Massachusetts 02155.

FELLOWSHIPS IN FOREST RESOURCES

Research Fellowships in Forest Resources are awarded annually by Harvard University from the Charles Bullard Fund. These Fellowships carry stipends up to $15,000, the amount of each award depending on the professional status and needs of the recipient. The purpose of this program is to support advanced research and study by persons who show promise of making an important contribution, either as scholars or administrators, to forestry defined in its broadest sense as human use of forested environments.

Applications should be submitted by February 1 for any work plans to take place after July 1 of any given year. For further information write to Committee on the Charles Bullard Fund for Forest Research, Littauer Center 119, Harvard University, Cambridge, Massachusetts 02138.

HIGHER EDUCATION WORKSHOP

To improve the teaching of agriculture in colleges, the National Association of Colleges and Teachers of Agriculture will sponsor an IOTA Workshop for Higher Education, June 8–13, 1973, prior to its Annual Meeting.

Workshop registration fee will be $80.00 ($5.00 to be paid by NACTA for its members as of January 31, 1973). Participants will be responsible for their own travel and per diem expense arrangements.

For plans to be made, the number of participants must be known; therefore a $25.00 deposit before March 31, 1973 will be necessary. Make out checks or Purchase Orders to the *National IOTA Program* and mail (or direct inquiries) to: Dr. E. Grant Moody, Division of Agriculture, Arizona State University, Tempe, Arizona 85281. (Phone: 602–965–2446)

INTERNATIONAL NUTRITION PLANNING PROGRAM

The Massachusetts Institute of Technology has received a three-year grant of $230,000 from the Rockefeller Foundation to begin an International Nutrition Planning Program that will provide a multidisciplinary approach to problems of malnutrition in low-income countries.

Heading the program will be Dr. F. James Levinson, who has served as chief of the Nutrition Branch of USAID in India and as consultant to The Brookings Institution and the World Bank. The program's plans include advisory services to governments and to international agencies involved in nutrition planning and programming; training programs for nutrition and planning personnel from low-income countries; and problem-oriented research on various national and regional strategies to combat malnutrition.

SOCIETY OF CHEMICAL INDUSTRY: PESTICIDES GROUP

An international conference on "Economic and Social Values in the Assessment of Crop Protection and Pest Control Methods" will be held by the Society of Chemical Industry at the University of Stirling, Scotland, Sept. 9–11, 1973.

The major topic is cost/benefit assessment of crop protection and pest control methods. In addition to invited lecturers and expert discussion panels, information is invited concerning relevant case studies whether successes or failures. Write to M. B. Green, Chairman, Pesticides Group, Society of Chemical Industry, 14 Belgrave Square, London, S.W.1, England.

OUTLETS FOR AGRICULTURAL ECONOMICS MANUSCRIPTS

Kansas State University has published a list of 62 journals that accept agricultural economics manuscripts. The types of articles are described, and ratings are given for rigor and use of mathematics. The publication was prepared by James Trapp and John Sjo. Write Department of Economics, Kansas State University, Manhattan, Kansas 66506 and ask for Staff Paper Series 3.

News Notes

UNIVERSITY OF ARIZONA

Appointments: **Ron S. Boster,** with the U. S. Forest Service, as adjunct assistant professor; **Robert S. Firch,** professor, as acting head of the Department of Agricultural Economics, replacing **Jimmye S. Hillman** who is on sabbatical leave at Oxford University; **Gayle S. Willett,** formerly with the University of Wisconsin, assistant professor.

UNIVERSITY OF ARKANSAS

Reassignment: **Kenneth R. Cupples,** as grain merchandiser with Central Soya, Inc., following completion of master's degree work.

Resignation: **Clyde A. Stuart, Jr.,** instructor, to become associate county agent with the Arkansas Cooperative Extension Service in Independence County.

UNIVERSITY OF CALIFORNIA, BERKELEY

Return: **Jerome B. Siebert** has returned to become associate director of Agricultural Extension after a three year assignment with USDA, most recently as special assistant to the Secretary of Agriculture.

CLEMSON UNIVERSITY

Appointment: **W. Allan Tinsley,** formerly with Michigan State University, associate professor.

COLORADO STATE UNIVERSITY

Appointment: **Donald D. Rodhy,** professor, as vice president for University Services.

Leaves: **Albert Madsen,** professor, on a two-year assignment in Panama with the AID/Colorado State University program as agricultural marketing extension specialist; **George Radosevich,** assistant professor, on a one-year assignment as economic affairs officer, United Nations, New York.

CORNELL UNIVERSITY

Appointments: **David Barton,** assistant professor; **Winfried Manig,** Ethio–German Agricultural Research Station, Ethiopia, visiting research scholar; **Morio Mese,** associate professor, Okayama University, Japan, visiting research scholar; **Karl Weckman,** University of Helsinki, Finland, visiting research scholar.

ECONOMIC RESEARCH SERVICE, USDA

(EDD, Economic Development Division; ESAD, Economic and Statistical Analysis Division; FDCD, Foreign Demand and Competition Division; FDD, Foreign Development Division; FPED, Farm Production and Economics Division; MED, Marketing Economics Division; NRED, Natural Resources Development Division.)

Appointments: **Richard Haidacher,** ESAD; **Charles E. Hanrahan,** FDCD; **Gene R. Hasha,** FDCD; **Linwood Hoffman,** MED; **Jitendar S. Mann,** MED; **Richard Reidinger,** FDCD.

Reassignments: **Lloyd D. Bender,** EDD-Columbia, Missouri, to Bozeman, Montana; **Alan R. Bird,** EDD, designated liaison officer with Virginia State College, Petersburg, Virginia; **Ivery D. Clifton,** FPED-Washington, D.C., to St. Paul, Minnesota; **Gary Davis,** FPED-Washington, D.C., to East Lansing, Michigan; **J. Albert Evans,** FPED-Pullman, Washington, to Washington, D.C.; **Arthur Gerlow,** FPED-Baton Rouge, Louisiana, to Washington, D.C.; **Howard Hogg,** FDD to NRED, Honolulu, Hawaii; **James B. Hottel,** FPED-College Station, Texas, to Washington, D.C.; **Edward V. Jesse,** MED-Washington, D.C., to Davis, California; **Donald K. Larson,** FPED-Bozeman, Montana, to Washington, D.C.; **Leon Perkinson,** EDD-East Lansing, Michigan, to Raleigh, North Carolina; **Charles N. Shaw,** MED-University Park, Pennsylvania, to Washington, D.C.; **Dorwin L. Williams,** FPED-Columbia, Missouri, to Lafayette, Indiana.

Leave: **Nancy Hancock,** FDCD, one-year study leave at Antioch College; **Abner Womack,** ESAD, two-year leave at the University of Minnesota.

Resignations: **Rex F. Daly,** ESAD, to AID/Thailand; **John A. Dempsey, Jr.,** ESAD, to Cost of Living Council; **Ralph A. Freund, Jr.,** ESAD, to Environmental Protection Agency; **Meyer Harron,** ESAD, to Treasury Department; **Norman Rollag,** MED, to Soil Conservation Service, Huron, South Dakota: **Ray Sassani,** ESAD, to Borden Food Company; **Michael P. Steiner**, MED, to the Price Commission.

UNIVERSITY OF HAWAII

APPOINTMENTS: **Peter V. Garrod**, assistant agricultural economist and assistant professor; **Gene E. Pollock**, The College of Wooster, visiting professor; **Gary R. Vieth**, assistant agricultural economist and assistant professor.

UNIVERSITY OF ILLINOIS

APPOINTMENTS: **Ming T. Lee**, research associate; **A. S. Narayanan**, research associate; **Robert H. Orr**, research associate; **C. Robert Taylor**, research associate.

AWARD: **R. N. Van Arsdall**, awarded the USDA Superior Service Award.

LEAVE: **E. D. Kellogg**, on a one-year assignment with USDA-Washington, D.C.

RETURNS: **A. G. Harms**, from two years at Njala University College, Sierra Leone, West Africa; **S. W. Williams**, from three years at J. Nehru Agricultural University, Jabalpur, India.

IOWA STATE UNIVERSITY

APPOINTMENTS: **Edwin J. Longfellow**, instructor; **Rudolph K. Schnabel**, instructor.

RESIGNATIONS: **Allan P. Rahn**, instructor, to the University of Georgia as assistant professor; **Thyrle Robertson**, assistant professor, to resume permanent post as OAS technician in Peru.

UNIVERSITY OF KENTUCKY

APPOINTMENT: **John C. Gamble**, assistant extension professor.

REASSIGNMENT: **Russell H. Brannon**, on leave with Kentucky/AID Team in Khon Kaen, Thailand, reassigned to Chief of Party.

MCGILL UNIVERSITY

POSITION AVAILABLE: Agricultural economist, Macdonald College, McGill University. Farm production economics and resource economics. Lecturer (instructor) to associate professor. Bilingual English-French preferred. Write David L. MacFarlane, Box 224, Macdonald College 800, Quebec, Canada.

THE UNIVERSITY OF MANITOBA

RETURN: **Sol. Sinclair**, to full-time appointment in the Department of Agricultural Economics, after retiring as director of the Natural Resource Institute; recently appointed a member, Fisheries Research Board of Canada.

UNIVERSITY OF MASSACHUSETTS

APPOINTMENT: **Cleve E. Willis**, assistant professor.

LEAVE: **John H. Foster**, professor, one year at the East-West Center in Hawaii under an Invitational Senior Fellowship from the Food Institute of the East-West Center.

MICHIGAN STATE UNIVERSITY

APPOINTMENTS: **Sherrill Nott**, assistant professor; **Harold Riley**, acting chairman.

RESIGNATION: **Gail Updegraff**, assistant professor, to O.E.O., Washington, D.C.

UNIVERSITY OF MINNESOTA

APPOINTMENTS: **Hans P. Binswanger**, research associate; **Thomas J. Daves**, assistant professor, appointed Acting Party Chief for the Minnesota-Tunisia project, underwritten by the University of Minnesota/AID contract; **Christine J. Hager**, research specialist.

RESIGNATION: **Herman J. VanWersch**, assistant professor, to the International Bank for Reconstruction and Development, Washington, D.C.

RETURN: **K. William Easter**, associate professor, from a two-year assignment as program adviser in agricultural economics under a University of Minnesota-Ford Foundation contract.

THE UNIVERSITY OF NEBRASKA

APPOINTMENT: **Donald G. Frahm**, assistant professor.

UNIVERSITY OF NEVADA

APPOINTMENTS: **Stephen P. Hass**, extension economist; **Hans Radtke**, community resource development specialist.

UNIVERSITY OF NEW HAMPSHIRE

APPOINTMENT: **Douglas E. Morris**, assistant professor of resource economics.

NEW MEXICO STATE UNIVERSITY

APPOINTMENTS: **Milton M. Snodgrass**, professor, formerly with California Polytechnic Institute; **Raymond J. Supalla**, assistant professor.

FOREIGN ASSIGNMENT: **Clyde E. Eastman**, development sociologist, completed four months with the New Mexico State University AID Paraguay.

REASSIGNMENT: **Charles H. Greene**, to the New Mexico State Department of Agriculture as chief of the Division of Markets.

OKLAHOMA STATE UNIVERSITY

LEAVE: Vernon R. Eidman, six-months' sabbatical leave at the Agricultural College of Sweden.

RESIGNATION: Allan R. Tubbs, to become President of the First Central Bank of DeWitt, Iowa.

THE PENNSYLVANIA STATE UNIVERSITY

APPOINTMENTS: Sam M. Cordes, assistant professor; **J. Frank O'Connor,** assistant professor.

LEAVES: Milton C. Hallberg to Dairy Group, MED, ERS, USDA; **Wayne A. Schutjer** to Ford Foundation, Bangkok.

RETIREMENT: William L. Barr, professor of farm management, after 36 years of service.

PURDUE UNIVERSITY

APPOINTMENT: Vernon D. Ryan, assistant professor.

HONOR: G. Edward Schuh, professor, received a diploma of recognition and honor from the Brazilian Society of Agricultural Economists for his assistance during the past 10 years in developing the agricultural economic profession in Brazil.

TEXAS TECH UNIVERSITY

APPOINTMENTS: Mark L. Fowler, professor, to chairman of the Department of Agricultural Economics; **Billy G. Freeman,** assistant professor; **James E. Osborn,** professor, to acting assistant dean for Research Programs, College of Agricultural Sciences.

AWARD: Sujit K. Roy, associate professor, Aggie Council Outstanding Teacher of the Year in the College of Agricultural Sciences.

LEAVE: Thomas R. Owens, associate professor, on leave to USAID in Saigon.

RESIGNATIONS: Richard J. Foote, professor, to USDA/USAID in Saigon; **Herbert W. Grubb,** professor, to manager of the Division of Management Science, Office of Information Services, Office of the Governor of Texas.

RETIREMENT: Archie L. Leonard, associate professor, after 25 years in the department.

UTAH STATE UNIVERSITY

APPOINTMENT: Paul Grimshaw, to assistant Dean, College of Agriculture.

THE UNIVERSITY OF VERMONT

APPOINTMENT: Robert O. Sinclair, as acting chairman of the Department of Resource Economics.

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

APPOINTMENT: Joseph D. Coffey, professor and head of the Department of Agricultural Economics, formerly with Office of the Secretary, USDA.

UNIVERSITY OF WISCONSIN

APPOINTMENTS: Walter R. Butcher, Washington State University, visiting professor; **Francis W. Groves** to chairman of the University Center for Cooperatives; **David J. King,** University of Wisconsin Contract team at the University of Ife, Nigeria, visiting assistant professor; **Luther G. Tweeten,** Oklahoma State University, visiting professor.

RETURNS: Robert H. Reed, after a four-year assignment under the USAID/Wisconsin Contract at the University of Rio Grande do Sul, Porto Alegre, Brazil; **John D. Strasma,** after 30 months as program advisor with the Ford Foundation, Office for Latin America and the Caribbean, in Chile.

THE UNIVERSITY OF WYOMING

APPOINTMENT: Harley J. McKinney, community resource development specialist.

OTHER APPOINTMENTS

Rais Ahmed, Ph.D. Michigan, returned to Planning Commission, Dacca, Bangladesh.

Claudio Barriga, Ph.D. Wisconsin, professor, Departmento Administracion de Empresas Agriciolas, Instituto Technologico de Monterrey, Monterrey, N. L., Mexico.

Theodore J. Blank, M.S. Purdue University, agricultural credit representative, Irwin Union Bank & Trust, Columbus, Indiana.

Peter J. A. Brouwers, M.S. Wisconsin, with the Instituto de Estudos a Pesquisas Economicas, Universidad de Federal, Rio Grande do Sul, Porto Alegre, Brazil.

Robert B. Brown, M.S. Purdue, instructor in insurance, Purdue.

Rey Estanislao Crystal, M.S. Wisconsin, to the Office of the Vice Mayor, Cebu City, Philippines.

Brady J. Deaton, Ph.D. Wisconsin, assistant professor, Department of Agricultural Economics & Rural Sociology, University of Tennessee, Knoxville, Tennessee.

Sanford B. Dooley, Ph.D. Purdue, resource development specialist, Louisiana Cooperative Extension Service, Louisiana State University.

Howard L. Engstrom, M.S. Minnesota, National Academy of Sciences, Washington, D.C.

Noralyn M. Ewart, Ph.D. Purdue, assistant professor, San Francisco State College, California.

Abiodun O. Falusi, Ph.D. Cornell, as research fellow, Nigerian Institute Social and Economic Research (NISER), University of Ibadan, Nigeria.

John D. Graham, Ph.D. Purdue, assistant professor, University of British Columbia, Vancouver, Canada.

Clayton Grant, Ph.D. Clemson, associate professor, Jacksonville State College, Jacksonville, Alabama.

David R. Graves, Ph.D. Purdue, research economist, FCS, USDA, Washington, D.C.

William W. Hall, Ph.D. candidate Clemson, research economist and editor, Economic Development Center, Western Carolina University, Cullowhee, North Carolina.

Rana Anwar Khan, Ph.D. Wisconsin, assistant professor, A & T State University, Greensboro, North Carolina.

Werner Kiene, Ph.D. Michigan, joint appointment with Ford Foundation, New York.

Gordon A. Leaman, M.S. Purdue, premanagement trainee, Oscar Mayer, Madison, Wisconsin.

Franklin J. Levinson, Ph.D. Cornell, assistant professor of international economics and nutrition, Massachusetts Institute of Technology.

Kenneth Miller, three-month period advising the Development Bank for Legal Amazonia, Brazil, and part-time assignment with the University of Missouri College of Administration and Public Affairs.

Mohamed Noor, Ph.D. Michigan, returned to University of Malaysia.

Kenneth E. Ogren, formerly deputy assistant administrator, FAS, USDA, to U.S. Embassy, Paris, as agricultural attaché.

Carl L. Pherson, Ph.D. candidate Minnesota, assistant professor, California State University of Fresno.

Michael J. Phillips, Ph.D. Purdue, to Farmer Cooperative Service, USDA, Washington, D.C.

Robert M. Pope, Jr., Ph.D. candidate Clemson, staff economist, Department of Marine Sciences, Center for Wetland Resources, Louisiana State University.

Edwin C. Price, Ph.D. Kentucky, staff economist, Federal Reserve Board.

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Monroe H. Rosner, Ph.D. Wisconsin, project associate with the Institute for Environmental Studies, University of Wisconsin-Madison.

Thomas Sharratt, M.S. Purdue, into the U. S. Army.

Lawrence N. Smith, Ph.D. Purdue, economics instructor, State University of New York at Geneseo.

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Joseph Weiss, Ph.D. Cornell, Compania Brasileira de Alimentos (COBAL) marketing economist in Brasilia for two years financed by AID.

OBITUARY

Walter A. Rowlands, 75, Emeritus Professor at the University of Wisconsin-Madison, died October 13, 1972, of a heart attack.

Rowlands joined the University of Wisconsin Extension staff in 1921 after serving in World War I and graduating from the Ontario Agricultural College at Guelph, Ontario, Canada. By the time of his retirement in 1966, he had become a national authority on land use planning, rural zoning, and resource development. In addition to his work in establishing county forests and developing industries based on agriculture, forestry, and recreation, he was supervisor of county agents in northern Wisconsin for 23 years. In 1968 Professor Rowlands received the Superior Service award of the USDA for his efforts in establishing the first comprehensive rural zoning ordinance in the United States and in land use planning.

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POLICY
INTEGRATION
IN
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ROBERT CROWN EARL O. HEADY

Examining the fundamental problems of Canadian agriculture and why programs to date have failed to solve them, Crown and Heady propose two major changes in the policy-generating environment that could set a new direction for agricultural policy conducive to the evolution of workable agricultural programs. These entail first, encouragement by government of a line of communication between itself and the more general farming population, rather than the producers of specific commodities; and secondly, the development of programs that recognize the existence of both commercial and noncommercial farm families and meet the needs of each.

Granted those changes, the authors believe that a non-commodity approach to agricultural policy is entirely feasible. They point out that most existing programs for individual commodities can be eliminated (with considerable treasury savings) if (1) programs are developed and aimed directly at the income problems of commercial and noncommercial farmers, and (2) if government provides the arena in which adjustment of the sector can proceed at the rates needed to generate adequate farm incomes for the active participants of the future. Moreover, they make recommendations for the new income policies for commercial and noncommercial farmers, and discuss the possibilities and problems of achieving ongoing adjustment and dealing with supply management for agricultural products.

Most significantly, this study illustrates the economic and political feasibility of the proposed changes and shows how they could be financed from existing appropriations. While the book deals specifically with Canadian agriculture, its conclusions, directions, and recommendations are applicable to other developed and developing countries.

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Costs and Returns of Education in Five Agricultural Areas of Eastern Brazil*

George F. Patrick and Earl W. Kehrberg

This study tests the hypothesis that education has a major role in agricultural development by estimating costs and returns of schooling and extension in areas at various modernization levels. Public and private costs are estimated from secondary information and farm surveys. Value-added and auxiliary equations, estimated from farm-level data, are used to derive annual returns of education. Although based on weak statistical results, schooling returns are negative or low, but increase with modernization level. Extension returns are generally high for individuals, but cover social costs in only two geographic areas. This suggests education's role in development may be limited.

It has been hypothesized that education plays a major role in agricultural development. However, studies of the economics of education in the agricultural sector have been based largely on aggregate data from developed countries [4, 6, 11, 20]. Studies in developing countries have focused on the nonagricultural sector, while the agricultural sector has been almost entirely neglected with the exception of [3, 8].

This study estimates the costs and returns to formal schooling and agricultural extension in five areas representing different levels of agricultural modernization. The first section discusses education's role in agricultural production. The second section describes the model used to measure the returns to education. The third section describes the areas studied. Fourth are the statistical results and estimated returns to schooling and extension. Fifth are the estimated costs of education, followed by the benefit-cost ratios and internal rates of return. Implications of the results are contained in the final section.

Education's Role in Agricultural Production

One way of conceptualizing the role of educational activities (schooling or extension) in agricultural production is to consider education's impact on production of a firm. Welch [20] has attributed the value of education to a "worker effect" and an "allocative effect" which are directly related to the labor and managerial input components of the human factor. The worker effect arises because increased education may improve the quality of the labor component and can be defined as the ability to produce more, given the same resources other than labor.[1] Increased education may also improve the decision–making functions of the managerial component by increasing the farmer's ability to acquire, interpret and evaluate information, giving rise to the allocative effect.[2]

The allocative effect has two aspects. The first refers to the allocation of resources, in the case of a multiproduct firm, among competing products. In a market–oriented agricultural environment with changing product and/or factor prices there is typically continued need for adjustment in resource allocation, although production techniques and types of inputs may be constant. More nearly optimum allocations of resources among products by farmers with more education would be reflected by greater output, other factors being constant.[3] Determination of the types and quantities of resources to be used in production is the second part of the allocative effect. Farmers with more education may adjust production plans according to changes in input prices and may be able to identify and utilize properly "new" inputs. In the short run the types and quantities of purchased inputs can be changed, while the

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George F. Patrick *is a Ford Foundation Project Specialist/Brasil.* Earl W. Kehrberg *is professor of agricultural economics at Purdue University.*

[1] This is essentially the "quality" of labor as considered by Griliches [7].

[2] In part this includes the "innovative" effect discussed by Nelson and Phelps [15].

[3] Increased education may also improve a farmer's ability to predict seasonal price variations. If prices received by an individual farmer, rather than average regional prices, were used to compute gross output, measures of the return to education would include the "price effect," if it exists.

types and quantities of firm–supplied resources can be changed in the long run.

With the transformation or modernization of agriculture, alternative production techniques and "new" inputs are developed. Farmers must continually evaluate alternative production techniques, resource and product combinations. If education aids farmers in allocative decisions, returns to education hypothetically will be higher in areas with more modernized agriculture.

Assuming well–defined market values for farm outputs and inputs, other than operator labor–management, value–added by education and labor-management could be calculated as a residual. This value–added, as an appropriate function of education and operator labor-management, would yield a partial derivative that could serve as a measure of the marginal value–added by a unit of education. In essence this would be the marginal value product of education, aggregating all of the above effects of education for any given level of operator labor. Although conceptually simple, the complete value–added approach is difficult to implement because the market values of many inputs are not well–defined in the real world, particularly in underdeveloped countries, and problems of operational definition and measurement arise with respect to all of the variables. Alternatively education could be included as an explicit variable in a traditional production function. However, since education may affect the allocation of resources, the partial derivative with respect to education could underestimate its marginal value product.[4]

Assuming that the value of output, Y, is a function of factor services, X, and education, E, the relationship can be expressed as

$$(1) \qquad Y = f(X, E).$$

If education does affect the choice of type and quantity of resources, then

$$(2) \qquad X = g(E),$$

and it follows that

$$(3) \qquad \frac{dY}{dE} = \frac{\partial Y}{\partial E} + \frac{\partial Y}{\partial X} \cdot \frac{dX}{dE}$$

with $\frac{dX}{dE}$ based on (2).

The first term on the right of the equality sign in Equation (3) includes the direct effect of education on production, and the second term is the *gross* indirect effect of education on production through the other inputs. If these other inputs are measured in value terms, then $\partial Y/\partial X$ is the marginal value product of X, which at the optimum level of input use equals the price of X. The *net* indirect effect of education can be represented as

$$(4) \qquad \left(\frac{\partial Y}{\partial X} - P_X\right) \cdot \left(\frac{dX}{dE}\right)$$

and the *net* marginal product of education as

$$(5) \qquad \frac{dY}{dE} = \frac{\partial Y}{\partial E} + \left(\frac{\partial Y}{\partial X} - P_X\right)\left(\frac{dX}{dE}\right).$$

Estimates of $\partial Y/\partial E$ and $\partial Y/\partial X$ may be obtained by estimation of (1), while an estimate of dX/dE may be obtained by estimation of the auxiliary equation (2).[5] Thus this procedure will yield an estimate of the marginal value product of education which includes all of the worker, allocative, and price effects.[6]

Statistical Model and Procedures

A modified version of the value–added function was estimated to obtain an empirical measure of education's impact on agricultural output in each of the areas studied. The specific form of the model was

$$(6) \qquad \begin{aligned} \log VA &= \log b_0 + b_1 Sch + b_2 Ext \\ &\quad + b_3 \log FC + u. \end{aligned}$$

Value–added, VA, was defined as the value of farm production minus the value of purchased nonlabor inputs. Formal schooling, *Sch*, was measured as the years of schooling completed by the farm operator. Participation in extension activities, *Ext*, was measured by the number of direct contacts the farm operator had with the extensionist during the year studied. Farm–supplied services of labor, land, livestock, equipment, and other forms of fixed capital were aggregated into a single variable, FC.[7]

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[4] For a multiproduct firm in which the allocation of resources among products is not specified, the partial derivative of education will include worker effect and effect of allocation of resources among products but will exclude the effect of determining the "right" types and quantities of resources to be used [20].

[5] A similar approach has been used by Haller [8].

[6] The same procedure could be used for a partial value–added function where the value of inputs with well–defined market values was subtracted from output.

Many farmers in the areas studied do not have any formal schooling and/or have not participated in extension activities, yet have nonzero production. Specification of schooling and extension in linear form allows zero as a "legitimate" observation. The estimated coefficients can be interpreted as the percent change in value–added from a unit change in schooling or extension, that is, the direct effect of education on production.[8]

The indirect effect of education on the quantity of farm–supplied resources was estimated by the auxiliary equation

$$\log FC = b_0' + b_1' \, Sch + b_2' \, Ext + u. \tag{7}$$

Aggregation of the farm–supplied resources into a single variable excludes part of the effect of selecting the "right" types and quantities of resources. Part of this effect will be picked up by the value–added function, while the auxiliary equation will pick up primarily the effect of selecting the "right" quantity of farm–supplied resources. Correlations among the various forms of farm–supplied resources were extremely high, suggesting they should be aggregated into a single variable to avoid the estimation problems associated with high multicollinearity.

The estimated marginal product of schooling is the annual return accruing to the individual in the form of value–added and does not include other possible returns to schooling. It is assumed this return would accrue to an individual for 35 years beginning at age 20. It is assumed that 50 percent of the benefits from farmer's participation in extension activities in year t accrue to him in year t, 30 percent in year $t+1$, and 20 percent in year $t+2$.[9] A discount rate of 10 percent, the assumed real rate of interest, was used to obtain the present value of these income streams.

Data used in estimating the functions were obtained from surveys of farmers in five areas in 1969 [2, 5, 10, 13, 14]. Information obtained included years of school completed, number of contacts with extension agents, labor used, current value and expected life of fixed capital resources, purchased inputs, and gross farm output. The farmers also furnished information necessary to estimate the cost of their participation in extension activities, earnings foregone by their school age children, and direct costs of schooling. This study was limited to commercial farmers (normally more than five hectares).

Areas Studied

The areas studied in eastern Brazil represent a wide range of agricultural conditions and levels of agricultural development. Although there is considerable variation in soils, natural vegetation, topography, and agricultural enterprises among the areas, within each area agricultural conditions are relatively homogeneous. All areas have been served by the extension service for a number of years. The areas at the time of the study can be characterized in ascending order of agricultural modernization, as follows:[10]

Paracatu in the state of Minas Gerais is an area of relatively large farms with extensive grazing of beef cattle on natural pasture as the principal activity. Crop production has increased since the establishment of Brasília, but very little machinery is used and very few farmers use fertilizers. Although many of the production practices are quite traditional, some changes are occurring.

Conceição de Castelo in the state of Espírito Santo is an area of coffee production, and livestock is of minor importance. Farms are relatively small and often grow corn and dry beans in addition to coffee. Most farmers use traditional production techniques, although some use fertilizers and control erosion. There is a

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[7] Labor, a quasi–fixed factor in much of Brazil, was valued at the prevailing agricultural wage of the areas. Services of fixed capital (buildings, improvements, equipment, and livestock) were measured as depreciation, interest, and repairs. Land services were measured using a given area's average rental values to avoid using prices which have been distorted by individuals buying land as a hedge against inflation.

[8] A positive coefficient signifies a marginal product which is increasing at an increasing rate. This does not appear unreasonable within the range of the data as an additional year of schooling represents a larger investment in a more mature student, while additional contacts are often necessary for the extensionist to gain a farmer's confidence and reinforce teachings.

[9] Time distribution of the effects of extension was based on the judgment of the researchers and others familiar with the situation, but more research is necessary for verification. To the extent that the time distribution differs from that assumed, the benefit–cost ratios and internal rates of returns will be different from those estimated, possibly changing the economic and policy implications.

[10] The area ranking was based on modern input use, recent changes in the area, and consultation with Brazilian professionals. For a more detailed description of the ranking system and areas studied see Patrick [16].

Table 1. Parameter estimates and standard errors for the value-added function and auxiliary regression in the areas studied

Variable	Area Paracatu n=86	 C. de Castelo n=54	 A. São Francisco n=82	 Viçosa n=337	 Resende n=62
			Value-Added Function		
Constant	.94622	.43970	1.0038	−.20122	.71437
X_1 Schooling	−.01676 (.01191)	−.00919 (.01232)	−.01255 (.01932)	.02324*[a] (.00811)	.00993 (.00895)
X_2 Extension	.00056 (.00275)	.00901* (.00339)	.00432 (.00442)	.00268 (.00261)	.00099 (.00794)
X_3 Farm Resources (log form)	.72595* (.06885)	.93122* (.06285)	.67265* (.08982)	1.0116* (.04748)	.73426* (.10539)
R^2	.58577	.82461	.44205	.62376	.55092
			Auxiliary Regression[b]		
Constant	3.5924	3.1498	3.4272	3.2825	3.9289
X_1 Schooling	.05100* (.01814)	.00552 (.02744)	.07360* (.02264)	.03998* (.00908)	.03717* (.00994)
X_2 Extension	−.00585 (.00434)	.00434 (.00752)	.00019 (.00554)	.00729* (.00298)	.00869 (.00974)
R^2	.10148	.00920	.10771	.09000	.20308

[a] One asterisk indicates the coefficient is significant at the 1 percent level.
[b] Dependent variable is X_3, farm-supplied resources in log form.

tendency toward diversification of crops, and the extension service promotes production of washed coffee.

Alto São Francisco in Minas Gerais is an area of transitional agriculture, and part of the area has a reputation as a center of purebred cattle. Many farmers have established improved pastures and use mineral supplements, and some use protein supplements during the dry season. Crops, mainly corn and dry beans, are often used to prepare the land for establishment of improved pastures.

Viçosa in Minas Gerais is also an area of transitional agriculture. Coffee, the traditional crop, has declined in relative and absolute importance, and major adjustments have followed its decline. Many farms are small and have diversified production. Dairy and horticultural crops are increasing in importance, and many farmers use fertilizers and insecticides. Some farmers with dairy cattle are using supplemental pasture during the dry season and introducing Holstein blood.

Resende in the state of Rio de Janeiro has the most modernized agriculture of the areas studied and has specialization in milk production. The area is one of the more advanced dairy areas in Brazil. Most cattle carry a high proportion of Holstein blood and are intended for dairy, rather than dual purpose. Use of supplemental forage during the dry season and feeding of concentrates and mineral supplements are common.

Estimated Returns to Educational Activities

Estimated value-added and auxiliary functions for each of the areas studied are presented in Table 1. Educational activities were generally not statistically significant in the value-added functions, while farm-supplied resources were highly significant in all areas. In Viçosa and Resende the estimated coefficients of schooling were significant or larger than their standard error, but they were negative in the three less modernized areas. The estimated coefficients of extension were positive in all areas, but significant only in C. de Castelo. These results indicate that educational activities had limited direct impact on value-added in the areas studied.[11]

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[11] Information on recommended practices adopted by individual farmers was available for all areas except C. de

Indirect effect of schooling, measured in gross terms by the auxiliary equations, was highly significant in all areas except C. de Castelo, thus indicating the level of farm–supplied resources is affected by schooling. However, given the high cost of schooling in Brazil, it could be argued that farmers whose fathers were well-to-do may have had the opportunity to obtain more schooling and also received more farm–supplied resources.[12] The indirect effect of participation in extension activities was significant only in Viçosa.[13]

Prices of farm–supplied resource services exceeded their estimated marginal products at the geometric sample means in all areas except C. de Castelo. Over–utilization of resources in these areas, combined with positive coefficients of schooling and extension in the auxiliary equations, indicate net indirect effects were negative except for extension in Paracatu. As indicated below, the net indirect effects were generally small and affected the signs of the annual returns to education only in Resende. In part, the negative net indirect effects of education may be the result of improper specification and measurement of farm–supplied resource services. Alternatively, given the highly inflationary environment and negative real rates of interest on bank loans in Brazil during the 1960's, farmers may have been attempting to maximize their real asset position or growth rather than net income or value–added.[14]

Table 2. Estimated annual returns, in Cr$,[a] to various years of schooling completed and contacts with extension in the areas studied, 1967/1968[b]

	Area				
	Paracatu	C. de[c] Castelo	A. São Francisco	Viçosa	Resende
Years of Schooling					
1	− 217.7	− 48.1	−182.9	89.4	−75.7
2	− 396.1	− 99.9	−300.9	192.6	27.3
3	− 571.9	−151.2	−424.6	300.1	130.2
4	− 745.9	−200.4	−555.6	413.0	233.9
5	− 918.5	−249.0	−685.6	531.9	336.2
6	−1090.8	−298.2	−847.0	656.9	438.9
Extension Contacts					
1	17.3	54.1	26.9	11.2	−59.5
3	25.2	158.5	70.9	35.7	−35.6
5	34.2	267.3	119.7	61.6	−11.9
7	44.6	380.7	169.5	87.7	11.8
9	53.2	498.9	220.2	114.2	35.5
11	62.3	622.2	272.1	141.2	59.0
13	71.2	750.7	324.9	168.3	82.4
15	80.5	884.0	378.8	195.8	105.7

[a] During the 1967/1968 agricultural year the exchange rate increased from Cr$2.70 to Cr$3.20 per US$1.00.

[b] The marginal product of the *n*th year (or contact) may be computed by subtracting annual return of year *n*−1 from year *n*.

[c] Results for C. de Castelo refer to 1966/1967 agricultural year.

Table 2 presents the annual return to an individual who had completed various years of schooling (or extension contacts) compared to an individual with the same resources and no schooling (or extension contacts). Returns to schooling, computed from coefficients which were nonsignificant in the value–added functions, were negative for all levels in the three less modernized areas. Although the net indirect effect of schooling in C. de Castelo was positive (about Cr$4), it was not large enough to overcome the negative direct effect. In Viçosa schooling variables were significant in both equations, and although the net indirect effect was negative, returns to schooling were positive. The negative net indirect effect in Resende reduced annual returns by Cr$204 for the first year, but the direct effect was large enough so that positive returns existed for additional years of schooling. Although not conclusive, the statistical significance of the coefficients and estimated returns indicate the value of schooling tended to increase with the level of agricultural modernization as hypothesized.

Returns to participation in extension activities, generally computed from nonsignificant coefficients, were positive at all levels in the four less modernized areas. In Resende the negative net indirect effect reduced returns by Cr$75 to Cr$110 and was sufficient to overcome the positive direct effect until the level of seven contacts. Net indirect effects did not exceed Cr$12 in other areas. The generally small and nonsignificant net indirect effects of extension were not unexpected since many extension ser-

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Castelo. Farmers were divided into three categories by years of schooling completed: low (none); medium (one to three years); and high (four or more years). A chi square test indicated that significant differences in the number of practices adopted did exist among schooling levels in A. São Francisco and Viçosa. A similar test for extension activities indicated significant differences existed in Paracatu, A. São Francisco, and Viçosa. Farmers were classified by the number of extension contacts as low (none), medium (one to five contacts) and high (more than five contacts).

[12] The hypothesis that both a farmer's level of schooling and initial resource position may be affected by his father's income level cannot be tested with data available. However, regardless of a correlation between schooling and initial resources, if schooling does provide managerial skills, then changes and adjustments should occur over time. Since the farmers studied were not beginning farmers, it is assumed these adjustments have had time to occur.

[13] A model in linear form indicated that the interactions between schooling and extension were not significant at the 25 percent level in the areas studied.

[14] For a more extensive discussion of this Brazilian situation see [1].

Table 3. Components of per student costs of schooling and percentage of total cost borne by the individual, 1968

Grade Attended[a]	Annual Earnings Foregone[b] Cr$	Individual's Direct Costs[c] Cr$	Costs of Personnel and Supplies[d] Cr$	Costs of Building and Equipment[d] Cr$	Total Cost Cr$	Percent of Cost Borne by Individual %
P_1	25.56	83.69	42.40	13.80	165.45	66.1
P_2	47.04	90.83	42.40	13.80	194.07	71.0
P_3	61.43	92.64	42.40	13.80	210.27	73.0
P_4	78.47	125.79	42.40	13.80	260.46	78.4
G_1	75.73	329.02	56.50	16.56	487.81	85.0
G_2	107.01	405.19	56.50	16.56	585.26	87.5
G_3	149.11	425.74	56.50	16.56	647.91	88.7
G_4	193.51	546.28	56.50	16.56	812.85	91.0
C_1	211.90	685.16	56.50	19.32	972.88	92.2
C_2	299.57	685.16	56.50	19.32	1060.55	92.9
C_3	299.57	685.16	56.50	19.32	1060.55	92.9

[a] P, G, and C indicate primary, *ginásio* and *colégio* school cycles. Subscripts refer to the year within each cycle.

[b] Earnings foregone are adjusted for labor force participation, with the assumption that students begin school at age eight and could work 300 days per year if not studying. No discrimination was made between students 17 years of age and older.

[c] Includes tuition of students attending private schools. The number of observations did not permit estimation of years of the *colégio* cycle separately.

[d] Available data did not permit discrimination of costs by year of cycle attended or between *ginásio* and *colégio* for personnel and supplies. Only 40 percent of estimated per student costs in public schools are included for the *ginásio* and *colégio* cycles to reflect the percentage of students attending private schools.

vices activities were oriented toward improving production practices.

Returns to extension tend to be lower in the more modernized areas. In Resende, the most modernized area studied, numerous input suppliers may serve to replace the extension service as a source of information about new inputs and practices.[15] However, the extension service may be working with the "poorer" farmers in the more modernized areas, and statistical results may be reflecting the quality of farmer assisted rather than returns to the extension activities *per se*.

Estimated Costs of Educational Activities

Formal schooling

In Brazil primary school attendance for four years beginning at age seven is required by law, but compliance is far from universal. Many rural children do not begin school at age seven and/or fail to make normal progress. Most primary schools are publicly supported, and only about 3 percent of the students attend schools where they must pay tuition. The secondary school system consists of two cycles, the *ginásio* of four years and the *colégio* of three years. These schools are normally located in urban areas, and about 60 percent of the students attend private schools where they must pay tuition.[16]

Table 3 summarizes the components of the cost of schooling for an average male student in rural areas by grade attended in 1968. Annual earnings foregone were adjusted to reflect expected labor force participation by male students not in school and presumably able to work 300 days per year. The individual's direct cost included books, supplies, uniforms, and tuition of those in private schools, and transportation, room, and board of students attending schools away from home. Costs of personnel and supplies were derived from secondary sources and adjusted to reflect costs per student in 1968. Estimated costs of the physical plant and equipment included depreciation, repairs, maintenance, and interest on average investment. At the *ginásio* and *colégio* levels only 40 percent of the estimated costs per public school student were included to reflect the percentage of students attending private schools and paying tuition.[17]

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[15] Resende was the only area with data available where farmers assisted by the extension service had not adopted a significantly higher number of recommended production practices.

[16] See [9] for a further discussion of schooling in Brazil, but recently the educational system has been undergoing substantial change.

[17] For a further discussion of these costs and adjustments see [16].

All costs increased with grade attended, the largest increases occurring between cycles. Approximately 75 percent of the average primary school cost of Cr$200 per year was borne by the individual and represented about one-third of rural per capita incomes.[18] At the *ginásio* and *colégio* levels, total costs were about Cr$600 and Cr$1000 per year respectively, and about 90 percent of the costs were borne by the individual. Secondary school costs exceeded per capita incomes in the areas studied.[19] The high costs of schooling borne by the individual, relative to incomes, may be a major reason why only 51 percent of rural Brazilian children between the ages of seven and fourteen attended school in 1964.

Agricultural extension

The federal extension service, *Associação Brasileira de Crédito e Assistência Rural* (ABCAR), serves areas where about 52 percent of the rural population is located. Approximately 60 percent of its efforts have been devoted to production-oriented assistance and the rest to community development, home economics, and other programs.[20] The estimated public cost of production-oriented activities was Cr$120 per farm in 1968.

Of the farmers surveyed, 38 percent participated in extension activities and had an average of 9.65 contacts with the extension agent. Farmers estimated their costs, in terms of time and out-of-pocket expenses, of participation in extension activities as Cr$31.07 per year or Cr$3.22 per contact. Total cost of production-oriented extension activities was Cr$151.07 per farm or Cr$15.65 per contact in 1968. In contrast to schooling, 79 percent of the costs of extension were publicly supported.

Investments in Educational Activities

Annual returns to schooling in Paracatu, C. de Castelo, and A. São Francisco were negative at all levels; thus the payoffs to investments in schooling were negative for the individual and society. In Viçosa annual returns were positive, and the private benefit-cost ratios were 2.71, 2.73, 2.75, 2.66, 2.21, and 1.96 for the first through sixth years of schooling. Respective social benefit-cost ratios were 1.79, 1.87, 1.93, 1.93, 1.69, and 1.55. The internal rate of return was about 16 percent for the individual for the first four years of schooling and declined to 14.6 percent for the sixth year. The social internal rate of return was about 2 percent lower than the private rate at all levels. In Resende annual returns to schooling were negative in the first year. Private benefit-cost ratios for the second to sixth years of school were 0.39, 1.19, 1.51, 1.40, and 1.31 with internal rates of return of 5.3, 11.0, 12.5, 12.1, and 11.7 percent respectively. The corresponding social internal rates of return were 3.7, 9.0, 10.5, 10.4, and 10.2 percent.

Individual and social benefit-cost ratios and internal rates of return for various numbers of extension contacts are presented in Table 4. In general the private benefit-cost ratios and internal rates of return were very high, the latter exceeding 500 percent in C. de Castelo, 350 percent in A. São Francisco, and 100 percent in Viçosa. Returns for up to seven contacts were negative but were relatively high for nine or more contacts in Resende. Although returns to individuals' investments in extension activities were generally high, the social benefit-cost ratios, as measured in this study, exceeded unity only in C. de Castelo and A. São Francisco. In the other areas returns to extension activities did not offset society's cost of providing them.

Implications

Although the statistical results do not support strong conclusions with respect to education and are based on a limited geographical area, some implications can be drawn. Clearly, if educational activities alone increased farmers' incomes, ordinarily the statistical significance of the educational variables in the equations estimated would have been much higher than discovered.[21]

If returns in agriculture to schooling are zero or negative, as in three of the five areas studied,

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[18] The per capita gross national product in Brazil was Cr$1108 or approximately US$320 in 1968. Incomes in rural areas are about one-half the national average [18].

[19] In the United States, costs of primary and secondary schools were about 10 and 40 percent of per capita incomes in 1956 (based on Schultz [19]).

[20] Mosher [14] discusses the history and development of ACAR, the ABCAR agency in Minas Gerais. Later developments and a review of studies of ACAR are provided by Ribeiro and Wharton [17], while the present ABCAR system is described by Schuh [18].

[21] These results are consistent with the hypothesis that many variables affect agricultural development. Any of these variables can serve as a bottleneck to development, but the removal of a bottleneck without a balanced approach is unlikely to speed development greatly.

Table 4. Individual and social benefit–cost ratios and internal rates of return to various numbers of extension contacts in areas studied, 1967/68[a]

Number of Contacts	Area									
	Paracatu		Conceiçao de Castelo[d]		A. São Francisco		Viçosa		Resende	
	I[b]	S[c]	I	S	I	S	I	S	I	S
1	4.58	0.94	14.33	2.95	7.12	1.47	2.61	0.61	*[e]	*
	196	6	>500	131	>350	40	110	*	*	*
3	2.25	0.46	13.99	2.88	6.26	1.29	3.15	0.65	*	*
	87	*	>500	127	>350	29	143	*	*	*
5	1.81	0.37	14.16	2.91	6.34	1.30	3.26	0.67	*	*
	62	*	>500	129	>350	30	149	*	*	*
7	1.68	0.35	14.40	2.96	6.41	1.32	3.32	0.68	0.45	0.09
	54	*	>500	131	>350	31	153	*	*	*
9	1.57	0.32	14.68	3.02	6.48	1.33	3.36	0.69	1.04	0.21
	47	*	>500	135	>350	32	155	*	13	*
11	1.50	0.31	14.98	3.08	6.55	1.35	3.40	0.70	1.42	0.29
	42	*	>500	139	>350	33	157	*	37	*
13	1.46	0.30	15.29	3.15	6.62	1.36	3.43	0.71	1.68	0.35
	39	*	>500	143	>350	34	159	*	54	*
15	1.42	0.29	15.61	3.21	6.69	1.37	3.46	0.71	1.87	0.38
	37	*	>500	147	>350	35	161	*	64	*

[a] Internal rates of return (percent) are given in the second line.
[b] I = Individual.
[c] S = Social.
[d] Ratios and rates for C. de Castelo are underestimated since returns were estimated from 1966–67 data.
[e] * Indicates a negative benefit–cost ratio or internal rate of return.

there is serious question whether investment in schooling is the best use of scarce resources. However, only the economic returns accruing to the individual in the form of increased value-added were considered in this analysis. Both economic and noneconomic external benefits as well as other returns accruing to the individual were ignored. At the present stage of development, schooling may have its greatest impact on increasing mobility of rural youth and facilitating the rural–urban transfer.[22] Those who have benefited most from schooling may seek other employment or migrate from the area, leaving those who benefited least from their schooling. High complementarity, particularly for society, may exist between investments in schooling and other investments not considered in this study.

As noted previously, returns to schooling tend to increase with the level of modernization of the areas considered. In areas of more traditional agriculture, the number of alternative techniques available may be limited, giving farmers little opportunity to use the increased decision-making and managerial capacity developed by schooling. In Viçosa, a transitional area undergoing major adjustments, returns to investments in schooling were higher than in the more modernized area of Resende where agriculture is highly specialized.

The public sector could reduce costs of schooling borne by the individual by providing more public schools, particularly at the secondary level. However, a large portion of the population apparently has such low incomes that it is not sending the children to existing public primary schools and would probably be unable to send children to secondary schools even if more public schools were provided. If schooling is considered a means of improving individual and social welfare, public support of schooling may need to take the form of direct subsidies or payments to low-income families in addition to public schools to be effective.[23]

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[22] The Brazilian school system has had a classical orientation; thus material may have been of limited usefulness in agriculture or taught in a context such that its relationship to problems faced by farm operators was unclear.

Greater public support of extension, relative to schooling, may indicate that society feels a higher proportion of the returns from extension activities accrue to society. Farmers assisted by extension may become early adopters of a new technique and, as such, become the recipients of the benefits of early adoption. However, if the market is functioning properly, other farmers will adopt this new technology, and society will benefit through having either greater output at the same cost or the same output at lower cost. This spillover effect which accrues to society may be large enough to justify strong public support of extension although the returns considered in this study did not cover social costs in three of the five areas.

The results suggest that returns to extension activities are higher in less modernized areas, while schooling has higher returns in areas of more modernized agriculture. The short-term investments in extension may well serve to facilitate agricultural modernization, but the long-term investment in schooling may have high returns for the next generation of farmers if agriculture is modernized. The problem is one of balancing the allocation of resources currently available between modernization through extension and formal education of future farmers.

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[23] A free hot lunch program has substantially increased school attendance in some areas. Direct costs of schooling could also be reduced either by not requiring school uniforms or by providing them for low-income students. Currently there is some discussion of the possibility of direct payment to students.

References

[1] Alves, Eliseu, and G. Edward Schuh, "The Economic Evaluation of the Impact of Extension Programs: A Study of ACAR in Minas Gerais, Brasil," Dept. of Agr. Econ., Purdue University, mimeo.

[2] Castro, José Ramalho P. de, "A Cooperativa Agrária dos Cafeicultores de Venda Nova: A Comercialização e o Emprego de Novas Tecnologias, Conceição de Castelo, Espírito Santo, 1966/67," unpublished M.S. thesis, Universidade Federal de Viçosa, 1969.

[3] Chaudri, Dharam Pal, *Farmers' Education and Productivity: Some Empirical Results from Indian Agriculture*, Human Capital Paper 69:4, University of Chicago, 1969.

[4] Gisser, Micha, "On Benefit-Cost Analysis of Investment in Schooling in Rural Areas," *Am. J. Agr. Econ.* 50:621–629, Aug. 1968.

[5] Gonzales, Thomas Backer Ecos, "Diagnóstico do Uso dos Fatores de Produção de Leite e Sugestões para sua Maior Eficiência, Resende, R.J., 1967/1968," unpublished M.S. thesis, Universidade Federal de Viçosa, 1969.

[6] Griliches, Zvi, "Research Expenditures, Education and the Aggregate Agricultural Production Function," *Am. Econ. Rev.* 54:961–974, Dec. 1964.

[7] ———, *Notes on the Role of Education in Production Functions and Growth Accounting*, Center for Mathematical Studies in Business and Economics Rep. 6839, University of Chicago, 1968.

[8] Haller, Thomas Elmer, "Education and Rural Development in Colombia," unpublished Ph.D. thesis, Purdue University, 1972.

[9] Havighurst, Robert J., and J. Roberto Moreira, *Society and Education in Brasil*, Pittsburgh, University of Pittsburgh Press, 1965.

[10] Irias, Luiz J. M., "Avaliação do Módulo Rural Médio para a Região de Viçosa, 1967/1968," unpublished M.S. thesis, Universidade Federal de Viçosa, 1970.

[11] Kislev, Yoav, "Estimating a Production Function From U.S. Census of Agriculture Data," unpublished Ph.D. thesis, University of Chicago, 1965.

[12] Lessa, Carlos A., "Estudo da Estrutura do Capital Agrícola no Cerrado Mineiro para sua Dinamização Através do Crédito Agrícola," unpublished M.S. thesis, Universidade Federal de Viçosa, 1969.

[13] Maffia, Dalva Lucia, "Impactos das Modificações do Tamanho da Propriedade sôbre a Produção Agrícola, Município de Viçosa," unpublished M.S. thesis, Universidade Federal de Viçosa, 1969.

[14] Mosher, Arthur T., *Technical Co-operation in Latin American Agriculture*, Chicago, University of Chicago Press, 1957.

[15] Nelson, R. R., and E. S. Phelps, "Investment in Humans, Technological Diffusion and Economic Growth," *Am. Econ. Rev.* 56:69–75, May 1966.

[16] Patrick, George F., "Agriculture and Economic Development in Eastern Brazil," unpublished Ph.D. thesis, Purdue University, 1970.

[17] Ribeiro, José P., and Clifton R. Wharton, Jr., "The ACAR Program in Minas Gerais, Brazil," in *Subsistence Agriculture and Economic Development*, ed. Clifton R. Wharton, Jr., Chicago, Aldine Publishing Company, 1969.

[18] Schuh, G. Edward, *The Agricultural Development of Brazil*, New York, Praeger Publishers, Inc., 1970.

[19] Schultz, Theodore W., *The Economic Value of Education*, New York, Columbia University Press, 1963.

[20] Welch, F., "Education in Production," *J. Pol. Econ.* 78:35–59, Jan./Feb. 1970.

Trade Policy and Its Effect on the External Agricultural Trade of Chile 1945–1965*

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The relationship between external agricultural trade and economic incentives was examined under the hypothesis that a large proportion of the agricultural trade deficit in Chile in the 1945-1965 period resulted from commercial policies, particularly those relating to rate of exchange, price fixing in the internal market, export quotas, and high prices of some inputs originating in protected national industries. Negative rates of protection were estimated for wheat, beef, wool, and lamb, while barley was determined to have a neutral rate of protection. Alternative commercial policies could have reduced the agricultural trade deficit.

THIS study deals with the relation of external agricultural trade to the economic incentives prevailing in Chile in the period 1945–1965. A net exporter of agricultural products prior to World War II, after the war Chile became more and more dependent on external sources for its food supply. Official statistics show that by the beginning of the 1960's, Chile was a net importer of agricultural products to the extent of about US $100 million annually.[1] This gap in external agricultural trade was a direct consequence of a rate of growth of aggregate production of only 1.5 percent per year, well below the rate of increase in aggregate demand resulting from growth of population and of income per capita. (Between 1940 and 1965 the rate of growth of population increased from 1.4 percent per year to 2.7 percent per year.)

The specific hypothesis of this paper is that a large proportion of the trade gap is a consequence of the commercial policies of the time, especially in regard to rate of exchange, price fixing in the internal market, export quotas, and high prices of some inputs originating in highly protected national industries.[2]

The analytical model used is an extension of the theory of "effective protection" that considers explicitly the effects of rate of exchange and of internal price controls, as well as of import duties.

External Trade in Agricultural Products

Although Chile has been a net importer of agricultural products[3] since World War II, the extent of the trade gap probably has been overestimated in official statistics. The official statistics concerned with the balance of external agricultural trade (for example, those appearing in the CIDA Report [Comité Interamericano de Desarrollo Agrícola] and in the National Plan for Agricultural Development compiled recently by ODEPA [16] among others) include as agricultural imports products consumed in Chile but not producible there: tropical and semitropical products such as coffee, bananas, tea, and cotton.

As shown in Table 1, the balance of agricultural trade has been recalculated with nonsubstitutable products excluded. For sugar cane it is assumed that half the sugar imports can be economically substituted for locally produced beet sugar. Given the results of Fontaine's study [9] on the social costs and benefits of the Chilean beet sugar industry, this assumption possibly overestimates the true percentage of economic substitution.

Official statistics of the external trade balance also err in valuing the cost of imports made under the Agricultural Surplus Program of the United States (Public Law 480) at their contractual cost rather than actual dollar cost.[4] Imports under PL 480 fall under four "Titles." Only those under Title IV are paid for in dollars. Imports under Title I are paid for in national currency while those under Titles II and III are donated from organizations such as the Campaign against Hunger, Caritas, and Care. In Appendix Table I the figures relating to each Agreement are shown, with conditions of pay-

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* The author wishes to acknowledge the helpful comments of H. L. Myint, A. C. Harberger, H. G. Lewis, T. Josling, and S. de la Cuadra.

[1] See for example [16].

[2] This hypothesis is similar to that posed by T. W. Schultz [18] in his analysis of the Chilean situation.

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[3] A condensed historical perspective of the growth in production between 1915 and 1965 can be found in [19].

[4] A brief explanation of the adjustment between the contractual and the "real" cost of PL 480 imports is given in [19].

ment and the volumes of imports specified.

As Appendix Table 1 shows, the real cost in dollars represented 45 percent or 60 percent of the cif value (cost/insurance/freight) of agricultural imports under PL 480 Agreements, according as one calculates that 100 percent or 75 percent respectively of the loan to the Chilean Government can be treated as a donation.

The real cost in dollars of obtaining imports under PL 480 was less than the cost of importing the same products commercially or even of producing them locally. During the five year period from 1956 to 1960, 57 percent of total wheat imports were realized under PL 480.

The figures in the last two lines in Table 1 indicate that official statistics overestimate the real deficit by approximately US $35, 45, 50, and 55 million per year during 1946–50, 1951–55, 1956–60, and 1961–65, respectively. Most of the difference is accounted for by the inclusion of nonsubstitutable imports in the official statistics.

It is the contention of this paper, furthermore, that much of the "trade gap" shown on the last two lines of Table 1 would not have appeared had it not been for the international commercial policies followed by Chile in the period after World War II. However, this statement does not mean to suggest that Chile should have pursued a goal of self-sufficiency in the agricultural sector (or any other sector), though such a goal may be attractive politically. Whether self-sufficiency in agriculture is an acceptable economic goal involves the development of criteria for deciding what and how much Chile can produce efficiently, questions that are approached here.

Table 1. Balance of external trade of agricultural products, Chile, 1946–1965 (millions of dollars, yearly average)

	1946–50	1951–55	1956–60	1961–65
Imports				
Substitutable Products				
1. Crops	19.0	33.9	22.6	31.6
2. Dairy and meat	15.1	24.1	22.2	49.2
3. Sugar (1/2)	11.2	10.6	7.0	9.7
4. Lumber	1.8	3.4	4.5	3.7
5. Sub total	47.1	72.0	56.3	94.2
Reduction in value of imports under PL 480				
6. Assumption A*	—	—	8.3	2.2
7. Assumption B	—	—	5.8	1.5
Total Imports				
8. (5–6)	47.1	72.0	A 48.0	A 92.0
9. (5–7)	47.1	72.0	B 50.5	B 92.7
Exports				
10. Total exports	39.0	34.7	30.6	40.6
Balance (excluding inputs)				
11. Assumption A (10−8)	− 8.1	−37.3	−17.4	−51.4
12. Assumption B (10−9)	− 8.1	−37.3	−19.9	−52.1
13. Imports of inputs	5.4	14.5	14.3	27.2
Balance (including inputs)				
14. Assumption A (10−[8+13])	−13.5	−51.8	−31.7	−78.6
15. Assumption B (10−[9+13])	−13.5	−51.8	−34.2	−79.3
Imports of nonsubstitutable Products				
16. Coffee, tea, cotton, etc.	22.8	34.4	35.9	41.8
17. Sugar (1/2)	11.3	10.6	7.0	9.7
18. Sub total	34.1	45.0	42.9	51.5
Overestimation of imports				
19. (18+6)	34.1	45.0	51.2	53.7
20. (18+7)	34.1	45.0	48.7	53.0

Sources: Imports and exports of products from *Dirección de Estadísticas, Anuario de Comercio Exterior;* imports of agricultural surplus under Program PL 480—see Appendix Table 1; imports of inputs from *Dirección de Estadísticas, Anuario de Comercio Exterior* includes seeds, pesticides, agricultural machinery (according to the definition in *Arancel Aduanero* [customs tariffs booklet]), and fertilizers.

[*] Assumption A: total loan to the Chilean Government classified as a donation.
Assumption B: 75 percent of the loan classified as a donation.

The implicit tariff and its effect on the net value of external agricultural trade

This study attempts to measure the rate of protection afforded several agricultural activities in Chile as a result of Chilean trade policies during the period 1945–65. It also attempts to estimate the quantitative effects of this protection on the trade balance of agricultural products relative to a more "neutral" commercial policy.

The agricultural sector faced a rate of protection significantly less than that which prevailed on the average for the rest of the economy. Resources that could have been economically used in agriculture were reallocated toward the nonagricultural sector, and the deficit in the trade balance of agricultural produce grew. The resulting agricultural trade deficit is more a consequence of internal trade policy than of adverse conditions for Chilean exports in the world markets or of a lack of responsiveness.[5]

In Chilean agriculture the proportion of inputs generally brought from the nonagricultural sector is relatively high (although this is not true of importable inputs in the livestock sector). Because of this fact it is necessary in measuring the rate of protection to consider not only distortions of prices in the product market but also those in the factor markets. The latter distortions reflect discrepancies between market prices and social costs.

The rate of protection of each activity is measured by what can be called the "implicit tariff" for the activity. It is defined as the percentage excess of the actual value added (to importable inputs) in the activity over what would have been the value added if the output and importable inputs had been valued at prices prevailing in the international market at an equilibrium rate of exchange.[6] (The international prices used in calculating the implicit tariff are assumed to be given to Chile.) This implicit tariff measures the effects not only of tariffs (including prior deposits on imports) but also of the direct fixing of prices in the internal market, quantitative restrictions such as export and import quotas and prohibitions, and the rate of exchange.

If it were possible to adjust for all distortions that exist in the factor and product market, the resulting implicit tariff is an indicator of the social rate of effective protection. In these circumstances the relative ordering of activities obtained on the basis of the implicit tariff reflects their comparative advantages [4, pp. 354–355].

Supply and demand functions implicit in this analysis represent a long-term situation in Marshall's sense. By contrast, the short-term supply is probably very inelastic, and changes of relative net prices mainly cause transfers of income between producers and consumers without much effect on aggregate income.

Overvaluation of the rate of exchange.—If the rate of "implicit" *social* protection is to be evaluated, it would be unrealistic to take the social cost of the foreign currency as that indicated by the official rate of exchange, which has been subject to strict control since 1931.

From 1932 to 1965 Chile had a system of infrequent devaluations in the presence of high rates of inflation almost always more than 20 percent and often close to 50 percent annually. Furthermore, from 1938 to 1956 Chile had a complex system of multiple exchange rates. These produced great uncertainty concerning the real rate of exchange and furthermore resulted in a considerable overvaluation of the Chilean currency over periods of several years. In an effort to solve frequently recurring balance of payments problems, Chile attempted to reduce and possibly substitute imports by introducing increasing restrictions (tariffs, quotas, prohibitions) on selected imports, especially nonagricultural consumer goods.

The rise of tariffs compensated at least partially for the overvaluation of the Chilean currency, particularly in certain fields. But this was not the situation for agricultural imports, where nominal tariffs were relatively low. And, of course, it was not true for agricultural exports, since high tariffs imply a *lower* rate of exchange for exporters than otherwise could be true.[7] (However, some exports occasionally received subsidies in the form of cash rebates and preferential exchange.)

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[5] However, the structure of ownership of land and capital in Chilean agriculture, which was highly concentrated, was indirectly and probably a negative factor for the adoption of a commercial trade policy consistent with economic growth of the agricultural sector (this view can be found in the writing of Jorge Ahumada [1]).

[6] The term "implicit tariff" has been used by other authors to describe exclusively the effect of quantitative restrictions and the term "equivalent tariff" to describe the effect of specific taxes, prior deposits, and import surcharges. See, for example, [4, p. 350].

[7] That the average tariff on consumer goods in Chile was relatively high in comparison with the prevailing tariffs in industrial countries and also in other semi-industrial countries more involved in external trade is clearly seen in the results obtained by Maizel for 1937 and 1955 [14, pp.

Chile's exchange rate policy had direct and serious repercussions on external trade and in the relative development of import–competing and export activities. A few examples show the uncertainty and risk of distortion inherent in the system prevailing during the forties and fifties. First, beginning in 1938 a complex multiple exchange system was established which lasted until 1956. For example, in 1950–51 the price of the dollar expressed in Chilean pesos varied between 30 and 130 pesos. The 30 peso to the dollar rate was used to import sugar and medicines, 43 pesos to import tea, coffee, and other products, 50 pesos to import agricultural machinery, wheat, oils, and cotton, and 60 pesos for other imports. For capital transactions a rate of 100 pesos per dollar was used, and in the case of tourism 130 pesos.

In the export sector, between 1947 and the end of 1951 a system of "compensations" existed in which the exporters of selected products, e.g., wine, had the right (which could be sold) to import certain prohibited articles such as cutlery and other household goods at a rate of exchange different from the rate prevailing outside the system of compensations. During this period the "mixed" system was developed in which a proportion of the revenues in certain products was returned to the exporters at a variable exchange rate and the balance at a fixed rate, the proportion varying with the product. Moreover, the exporter received a different rate per dollar for goods exported to Argentina from that received for exports to the U. S. or Brazil.

A second example of the uncertainty inherent in the prevailing system in the forties and fifties is the fact that the level of exchange rate for sectors exposed to international prices deteriorated in actual terms. Although it is very difficult to discover empirically the nature of the imbalance, it is clear that exchange rate policy discriminated against export sectors and favored import substitution over the application of "efficient" protection.

In spite of its limitations, the purchasing power parity theory is used in this study as a working hypothesis to estimate the "equilibrium" rate of exchange. The theory postulates that the equilibrium rate of exchange varies approximately in proportion to the ratio of the level of internal prices of a given country to that of its principal partners in international trade.[8]

The theoretical limitations are very real. The theory fails to take into account shifts in demand for imports and the influence of capital flows; it fails to recognize variations in tariffs and only partly reflects variations in the structure of relative costs. Even so, its theoretical limitations are inversely proportional to the rate of inflation, which was exceptionally high in Chile.

Moreover, experience with the system of devaluation adopted by Chile during Frei's administration between 1965 and 1970, in which (monthly) devaluations of the official rate of exchange occurred, indicates that proportionally small devaluations avoid deterioration in the real value of the rate of exchange and natural uncertainty. This experience seems logically consistent with the purchasing power parity theory. Even allowing for the high price of copper, the level of Chile's international reserves went on rising considerably while the amount of private and public external debt was being reduced.[9,10] The proposed adjustment of the exchange rate can also be interpreted as a measurement of the effect of a devaluation of given magnitude on the net returns perceived by national producers.

The implicit tariff.—Principally developed by Balassa [3], Corden [5], and Johnson [13], the theory of effective protection shows that although nominal protection measured exclusively in relation to the end–product has an effect on the composition of *consumption*, its effect on the allocation of resources is not directly proportional to the nominal tariff. In

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141–144] and by Balassa for the postwar period [2]. This was relative to a commercial policy without quantitative or tariff restrictions in a situation in which an attempt was made to maintain full employment and equilibrium in the trade balance and in which the prices of the factors were inflexible downwards.

[8] $Et_1 = Et_0\ (Pa_1/Pa_0).\ (Pb_0/Pb_1)$ in which Et_1 and Et_0 represent the rate of exchange in the period t_1 and in the base period, respectively, and Pa and Pb represent the levels of prices in Chile and in the rest of the world respectively.

[9] The exchange rate adjustments were based on long–term expected variation of the relevant variables (price levels in Chile and the U. S., price of copper, etc.) with the explicit objective of minimizing distortions in the external sector of domestic inflation and reducing the necessity of a larger external debt. An explanation of the system and a brief discussion of its effect on the change in the external debt can be found in R. French Davis and C. Carrasco [6].

[10] A brief discussion of the selection of the base period and of the price index for the calculation of parity is available from the author upon request.

order to determine the effect of protection on the productive structure, the effects of tariffs on the prices of intermediate goods must be included. Since some agricultural activities in Chile use imported or importable inputs, the approach of the theory of effective tariffs is relevant.

In addition to import duties, the effects of the following should be taken into account: rate of exchange, direct price controls (on both inputs and products), and quantitative restrictions.[11]

Symbolically, the implicit tariff (Z) in an activity is equal to:

$$Z = \frac{V' - V}{V} \tag{1}$$

where V is the value added per unit of output at the international market price P and a parity rate of exchange, E_p; that is,

$$V = PE_p\left(1 - \sum_i A_i\right) \tag{2}$$

where $\sum_i A_i$ is the proportion of the total cost spent on importable inputs. Similarly, V' is the value added per unit of output prevailing in the internal market, so that

$$V' = PE_o\left[(1+t+t') - \sum_i A_i(1+t_i+t_i')\right] \tag{3}$$

where E_o is the official rate of exchange. t and t_i are import duties on the products and inputs respectively, and t' and t_i' respectively represent the effect of price controls and quantitative restrictions on the end product and the importable input. t' can be represented by

$$t' = \frac{P^d - PE_o(1+t)}{PE_o} \tag{4}$$

and t_i' by

$$t_i' = \frac{P_i^d - P_iE_o(1+t_i)}{P_iE_o} \tag{5}$$

where P^d and P_i^d are the internal price of the product and of input i respectively, and P_i is the international price of input i. In this formulation the effect of what is usually classified as "tariffs" can be kept separate from the effect of quantitative restrictions and price controls. Substituting (4) and (5) into (3) and collecting terms results in

$$V' = P^d - P\sum_i A_i \frac{P_i^d}{P_i}. \tag{6}$$

After replacement of V and V' in (1) by (2) and (6) respectively, the expression for the implicit tariff can be written as follows:

$$Z = \frac{P^d - P\sum_i A_i\left(\frac{P_i^d}{P_i}\right)}{PE_p\left(1 - \sum_i A_i\right)} - 1. \tag{7}$$

If the proportion of inputs imported in some activities is insignificant, i.e. $\sum_i A_i$ is close to or equal to zero, then equation (7) changes to:

$$Z = \frac{P^d}{PE_p} - 1. \tag{8}$$

Z and Z^* can have values greater than, equal to, or less than zero, as the value added per unit at internal prices is greater than, equal to, or less than that at international prices and a parity rate of exchange. If the value of Z is positive, then the protection of the activity is positive. This implies that exchange rate policies, price fixing, and duties allow producers in the activity to obtain a value added greater than that obtainable if international prices prevail. If the value of Z is negative, the aggregate internal value added is less than that obtainable on the international market. Effective protection would thus be expected to produce a displacement of nonspecific resources from activities receiving a relatively low rate of protection towards those receiving a high rate, depending on the rate of factor mobility.

In terms of this analysis, for an "efficient" productive structure in agriculture, the net price (or value added) to be paid to producers in an activity is that which makes Z zero. This implies that at the parity rate of exchange, *given* the level of restrictions on imports in force in the economy during the base period, the value added per unit at internal prices equals the value at international prices.

In calculating the implicit tariff for each of several agricultural activities, it is assumed that the parity rate of exchange does not depend on the external trade balance of agricultural goods. Furthermore, the study takes as given (exogenous) variables not only the parity rate of exchange but also the average level of protection in the economy and commercial policy for the principal export sector.

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[11] The existence of conventional nontariff controls such as the last two mentioned above requires the use of direct price comparisons [see equations (4) and (5) below] to measure the implicit tariff.

The effective rate of protection reflects value added per unit at internal prices relative to value added at world prices. The value added concept used here is a residual value, representing the sum of the return to all nontraded inputs such as labor, land, and some capital services. In practice this protection affects only the return of those factors the supply of which is not infinitely elastic. Although very little is known about the relevant elasticities, it is logical to expect that returns to land ownership would have been relatively more affected than other returns.

In relation to the level of employment, this protection will have relatively more effect on the more elastic factors of supply, as would have been the case of unskilled workers. Analysis of the effects on the return to each factor is not dealt with in this study.

Estimation of the coefficients A_i.—Ideally in calculating the implicit tariff Z, the value added V at international prices should be calculated with the cost coefficients A_i^w that would have prevailed under international prices for output and importable inputs. These coefficients generally will differ from the actual coefficients A_i^d used in calculating V', because of substitution effects resulting from differences between the P_i^d/P^d and P_i/P.

The difference between A_i^w and A_i^d depends not only on the ratio of P_i^d/P^d to P_i/P but also on similar ratios for other importable inputs and on the elasticities of substitution among the inputs. These elasticities are not known and generally are not easy to estimate. Of course, if the underlying production function for the activity were a Cobb-Douglas function, then $A_i^w = A_i^d$.

In this study has been used the common practice of estimating effective rates of protection by assuming that the underlying production function is a "fixed proportions" function in which the elasticities of factor substitution are zero; in that case

$$(9) \qquad A_i^w = A_i^d \frac{\dfrac{P^d}{P}}{\dfrac{P_i^d}{P_i}} = A_i^d \frac{\dfrac{P_i}{P}}{\dfrac{P_i^d}{P^d}} .$$

Clearly in a situation in which input prices are more distorted than product prices in the sense that $P_i^d/P_i > P^d/P$, then A_i^w will be understated and the implicit tariff will be underestimated.

Effect of the implicit tariff on production and net saving of foreign currency.—Relative to a situation in which $Z=0$ for an activity, the effect of the implicit tariff (Z) on the national output of the activity reflects the rate of response to changes in the net prices. The percentage change in output is equal to:

$$(10) \qquad \partial \log X = \epsilon Z$$

where X is the level of output of the activity and ϵ is the elasticity of supply of output with respect to Z. In the following equation from Johnson [13, p. 126],

$$(11) \qquad \epsilon = ev$$

where e is the elasticity of supply of output in the usual sense and v is the rate of value added to price:

$$(12) \qquad \begin{aligned} v = \frac{V}{P} &= \frac{P\left(1 - \sum_i A_i^w\right)}{P} \\ &= 1 - \sum_i A_i^w. \end{aligned}$$

Substituting in (11) results in

$$(13) \qquad \epsilon = e\left(1 - \sum_i A_i^w\right)$$

where e and $\sum_i A_i$ can be estimated.

The percentage effect on consumption of the product of the activity is equal to:

$$(14) \qquad \partial \log C = Z^* E$$

in which C measures the level of consumption (demand), Z^* is the implicit tariff defined in (8), and E is the price elasticity of demand for the product.[12]

Finally, the direct effect of the implicit tariff on the net value of imports, which are designated as savings of foreign currency, can be expressed by the following equation:

$$(15) \quad \partial M = P\left[\epsilon Z X_o\left(1 - \sum_i A_i^w\right) - E Z^* C_o\right].$$

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[12] The elasticities E and ϵ are long-term, including the "interrelated" effect between interdependent activities. The effect measured here for each activity assumes that a simultaneous variation has been produced in the level of protection in all the activities included in the analysis.

This is the absolute net change in the availability of foreign currency (measured in dollars) on moving from the existing situation to a situation of equilibrium. It is equal to minus the change in consumption value plus the change in output value, minus the value of imported inputs resulting from the change in production mentioned.

Period of analysis, selection of activities, and price information.—Direct action of the Chilean Government to control external trade and internal prices increased considerably after 1930. Control of foreign exchanges began about 1931, and the system of wheat price fixing was initiated. By 1940 controls had been extended to several other products. At the end of the thirties was instituted a system of multiple exchange which lasted until 1956. Moreover, during the forties a system of annual fixing of export quotas was imposed on agricultural products, and this was maintained until 1968. By the end of 1940 the Government already had the legal and administrative tools necessary to control to a high degree the structure of net agricultural prices in the internal market.

However, analysis begins with data from the 1940's and extends only to 1965. Before 1940 (and for some products, before 1947), the data necessary to measure the implicit tariff are not available. After 1965, when Frei's program of agrarian reform began, the data might include significant change in cost structure and level of response to prices.

The analysis covers five products: wheat, beef, wool, barley, and lamb. The first two were chosen as representative of the import competing sector. Between 1946 and 1960 imports of these two goods represented approximately 50 percent of the total value of agricultural imports technically subject to substitution by domestic production. Wool and barley were chosen as being traditional Chilean export products, while lamb is a marginal export. These three activities together represented around 30 percent of the total value of agricultural exports during the period from 1946 to 1960.

Prices.—Except for beef, international prices were taken from the annual FAO publications *The State of Food and Agriculture* [8], in which annual values (beginning in 1947) are given for the average world price of exports, expressed in U. S. dollars. For cattle on the hoof and for beef, the prices are for Argentina, the only country exporting such products to Chile.

For import goods the international prices are adjusted to show values cif Valparaíso, plus cost of handling in port and transport. Similarly, the export prices used are net fob prices plus the cost of handling in port and transport.

Domestic prices are the wholesale prices prevailing in Santiago during the season of greatest agricultural sales according to the series developed in 1968 by ODEPA, an official Government agency [16].

Estimation of $\sum_i A_i^d$ and $\sum_i A_i^w$.—Although annual estimates of the parity exchange rate and of both internal and international prices for each of the five products studied here were available for the 1947–1965 period, estimates of the importable input coefficients A_i^w and A_i^d have been constructed for only one "date." The estimates for cereals are shown in Appendix Table 2.

Physical input/output ratios are available for the agricultural sector only for 1961–62 in a national survey [10]. These physical input/output ratios for 1961–62 were multiplied by corresponding price ratios (input price/output price) for 1969–70 (the only date for which input price data were available) to obtain the estimates of the coefficients A_i^w and A_i^d.

For cereals the estimated value of $\sum_i A_i^w$ is 0.20 and of $\sum_i A_i^d$ is 0.266. For beef, lamb, and wool production both $\sum_i A_i^w$ and $\sum_i A_i^d$ were less than 5 percent and were assumed to be zero (Appendix Table 2). For cereals for 1969–70, domestic prices of importable inputs on the average were 20 percent higher than international prices at the official rate of exchange. Alternatively, in calculating the implicit tariff domestic and international input prices were assumed to be the same.

Estimates of the implicit tariff

The implicit tariff was calculated for each year 1947–65. For each of the five agricultural

Table 2. Estimates of the implicit tariff (Z), 1947–1965, Chile, annual averages[a]

	1947–50	1951–55	1956–60	1961–65
Import competing activity				
Wheat	−.43	−.25	−.16	−.67
Beef	−.45	−.29	−.39	−.25
Export activity				
Barley	−.30	−.*	**	***
Lamb	−.33	−.27	−.39	−.28
Wool	−.65	−.45	−.42	−.34

[a] Calculated employing the parity E_{pa} (First Quarter 1959 = 100), coefficients at world prices $\Sigma_i A_i = .20$ and an import price ratio of 1.2.

* 1951–1953: −.23 average; 1954–1955: +.25 average.

** 1956–1960: −.18, −.04, +.09, +.11.

*** 1961–1965: +.42, −.01, −.02, +.14, +.08.

products sensitivity analysis was made to measure the effect on Z of varying the parity rate of exchange, the coefficient of imported inputs $\sum_i A_i$, and the ratio of input prices. The use of different base periods to estimate the parity rate had much more influence on Z than varying $\sum_i A_i$ or the ratio of input prices.

Average values between 1947 and 1965 are presented in Table 2, using the parity E_{p1}, $\sum_i A_i$ equal to 20 percent and P_i^d/P_i equal to 1.2, values thought to be the best estimates. The values obtained indicate that production of wheat, beef, wool, and lamb were subject to negative effective protection during practically the whole period, averaging about $-.38$ for wheat, $-.35$ for beef, $-.30$ for lamb, and $-.46$ for wool. Barley production is the only activity without negative protection and the one subject to greatest instability, as seen in Table 2.

There is an absence of econometric studies of supply descriptive of the Chilean situation in the activities in question. Calculation of the effect of the implicit tariff on production and consumption in Chile was thus made for a range of values of the elasticity of supply, based on estimates obtained in studies about Chile and other South American countries.[13]

It is suggested here that an average value between 0.15 to 0.5 represents a realistic estimation of the range of long-term individual elasticity of supply (ϵ) when there are simultaneous changes in prices of other products under analysis. To test the sensitivity of the results, both values were used.

Table 3 presents the variation in agricultural production and in the net value of imports and exports during 1951–1960. For example, during the five year period 1951–1955 with a rate of exchange of Ep_1, the annual average level of production of wheat was approximately 3 percent to 10 percent less than the equilibrium level, accordingly, as elasticities of 0.15 or one of 0.5 are used. On the same basis, in the five-year period 1956–1960 production was 1.8 per-

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[13] R. Echeverría on Chile [7] estimated the short-term elasticity of supply for various crops; other estimates were made by L. Reca for cereals in Argentina [17]; W. C. Merrill for rice in Peru [15]; and W. H. Witherell for wool in Uruguay and Argentina [20].

Table 3. Variation in production and in the net value of imports or exports, Chile, annual average 1951–1960*

Growth in:	Rate of Exchange E_{p1}** Elasticity of Supply				Rate of Exchange E_{p2}** Elasticity of Supply			
	$\epsilon=0.15$		$\epsilon=0.50$		$\epsilon=0.15$		$\epsilon=0.50$	
	1951–55	1956–60	1951–55	1956–60	1951–55	1956–60	1951–55	1956–60
Production	Annual Percent							
Wheat	−3.0	−1.8	−9.9	−6.2	−1.9	−0.7	−6.4	−2.2
Beef	−4.4	−5.8	−14.5	−19.4	−3.1	−4.8	−10.4	−15.8
Lamb	−4.2	−5.9	−13.9	−19.5	−2.9	−4.8	−9.7	−16.0
Wool	−6.8	−6.3	−23.0	−21.0	−5.8	−5.3	−19.4	−17.8
Barley	0	0	0	0	0	0.1	2.0	3.5
Net Value of Imports or Exports	Millions of dollars							
Wheat *I****	7.3	3.5	12.7	6.8	5.1	0.7	8.6	2.1
Beef *I*	10.1	14.6	20.4	30.8	7.4	12.3	14.3	24.6
Lamb *E*	−1.3	−1.9	−2.6	−4.4	−0.9	−1.6	−1.8	−3.5
Wool *E*	−5.2	−4.1	−13.5	−10.9	−4.6	−3.6	−11.2	−8.9
Barley *E*	0	0	0	0	0	0.17	0	0.12
Net Value of Imports or Exports (without varying the level of existing consumption)	Millions of dollars							
Wheat *I*	1.7	1.0	6.0	3.5	1.0	0.3	3.7	1.2
Beef *I*****	3.6	5.3	13.9	21.6	2.5	4.3	9.4	16.6
Lamb *E*	−0.5	−0.8	−1.8	−3.3	−0.3	−0.6	−1.2	−2.5
Wool *E*	−2.5	−2.1	−10.8	−8.9	−2.1	−0.8	−8.7	−3.2
Barley *E*	0	0	0	0	0	0.04	0	0

* Calculated using coefficient of imported inputs ($\Sigma_i A_i$) equal to 0.20 (world prices) in cereals and zero in wool and beef products, and a ratio of input prices equal to 1.20.

** E_{p1} = First Quarter 1959 = 100; E_{p2} = annual average 1959 = 100.

*** I = Imports; E = Exports.

**** This activity becomes net exporting as much when $\epsilon=0.50$ as when $\epsilon=0.15$.

Table 4. **Effect of the implicit tariff on the exterior trade balance of some agricultural products, Chile 1951–1960**[a]

Period	Increase in the net value of		Loss of Foreign Exchange		Percentage reduction in the exterior agricultural deficit[b]			
	Imports	Exports	Consumption at existing level	Consumption at equilibrium level	Consumption at existing level		Consumption at equilibrium level	
	Consumption at existing level (millions of dollars p.a.)		(millions of dollars p.a.)		A percent	B percent	A percent	B percent
			Elasticity of supply 0.5					
1951–55	16.3	−12.8	29.1	39.4	56	47	76	63
1956–60	15.1	−12.3	27.3	33.8	86	70	100	87
			Elasticity of supply 0.15					
1951–55	5.3	− 3.0	8.3	23.9	16	13	46	38
1956–60	6.3	− 2.9	9.2	24.1	29	24	76	62

[a] Calculated with the parity rate of exchange: the First Quarter 1959 = 100 (E_{p1}), coefficient $\Sigma_i A_i = 0.20$ for cereals and zero for beef and wool, and a ratio of input prices equal to 1.20.

[b] Reduction in the deficit is calculated in relation to the substitutable deficit for domestic production according to the estimation in Table 1 (line 14, including imports of inputs).

In A and B it is supposed that only 50 percent and then 100 percent, respectively, of sugar imports are substitutable by domestic production.

cent to 6.2 percent less than the equilibrium level.

In beef the level of national output production during the five years 1951–1955 was 4.5 percent of 14.5 percent less than its equilibrium level; for wool the corresponding range of production was from 6.8 percent to 23 percent below equilibrium levels. Barley was at its equilibrium level of production.

Loss of foreign currency was estimated under two assumptions regarding the level of domestic consumption: (1) It is supposed that the authorities are prepared to subsidize consumption if necessary and maintain it at the level that actually prevailed during the decade 1951–1960; and (2) A price elasticity of demand of −0.3 was assumed.

Under the first assumption and given the elasticity of supply (ϵ) equal to 0.5, the results shown in Table 4 indicate that for the five activities taken together the cost in terms of deterioration in annual net income averaged approximately U. S. $29 million during 1951–1955 and U. S. $27 million during 1956–1960. Alternatively, if $\epsilon = 0.15$, the corresponding figures are U. S. $8.3 and U. S. $9.2 million respectively.

If consumption is adjusted to a level that would prevail at equilibrium, the average annual loss was estimated at U. S. $39 million for 1951–1955 and U. S. $34 million for 1956–1960 with $\epsilon = 0.5$, and U. S. $24 million and U. S. $24 million respectively with $\epsilon = 0.15$.

This potential saving of foreign currency was related to the actual deficit in balance of agricultural trade during the decade. Goods classified as nonsubstitutable were excluded, and two alternative assumptions regarding the import of sugar were used.[14] In the first case it is assumed that Chile can substitute for only half of its sugar imports while in the second case all its imports could be substituted.

For a supply elasticity equal to 0.5, the deficit in the agricultural balance was reduced by 56 percent during the period 1951–1955 and by 86 percent during 1956–1960, assuming internal consumption at the levels which actually prevailed and considering 50 percent of the imported sugar substitutable. Alternatively, the deficit was reduced by 47 percent and 70 percent during the first and second periods respectively, if all the imported sugar was substitutable.

At equilibrium consumption levels, the agricultural deficit was reduced by 76 percent during 1951–1955 and practically disappeared during 1956–1960. In fact, some import competing activities were transformed into marginal net exporters, e.g., beef. Alternatively, if 0.15 was used as elasticity of supply, the percentage reduction in external balance was approximately 30 percent of the values reported above for $\epsilon = .5$ when the existing levels of consumption were maintained, and approximately 70 percent of the values above at the equilibrium levels of consumption. These values are all reported in Table 4.

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[14] Before 1950 Chile did not produce sugar; a rigorous study of the social evaluation of the national sugar (beet) industry indicates that this industry yields positive net benefits only at exceptionally high international sugar prices, greater than those which prevailed in the decade [9].

Summary and Conclusions

Redefinition of the agricultural balance of trade suggests that the size of the deficit existing in Chile since World War II has been exaggerated, a consequence mainly of including nonsubstitutable goods among farm imports. For the 1950's approximately 40 percent of what is included in official statistics as farm imports is not substitutable. In spite of this, the net agricultural trade absorbs an important proportion of the total availability of foreign currency of the country.

Of the five commodities analyzed, only barley received a "neutral" rate of protection measured by the implicit tariff at the parity rate of exchange. The others received negative protection, and the rate of protection fluctuated around −.38 for wheat, −.35 for beef, −.46 for wool, and −.30 for lamb.

The results suggest that if during the 1950's Chile had opted for a commercial policy without negative protection for these farm activities, the trade balance deficit of agricultural goods would have been reduced to an insignificant level. The methodological limitations suggest a note of caution. The whole of the saving or direct foreign currency acquisition resulting from increased production of the five commodities analyzed would not necessarily be equivalent to a net contribution to the balance of payments of the country.

First, Chile's adoption of a policy to maintain the implicit tariff at the zero level might have created a pressure to raise salaries in the nonagricultural sector. Such pressure would have been due to increased prices of foodstuffs, an important component in the working class budget. The pressure could perhaps have been offset by fiscal and monetary policy. If not, higher salaries would have reduced the competitive capacity of the export sector.

Second, the average level of protection to the nonfarm sector is greater than that received by the agricultural sector. These results do not need to imply that—in a dynamic context—there might have been no economic advantages in expanding other activities instead of the farm activities analyzed. Answering this question requires knowledge of the structure of tariffs (implicit) in the whole economy as well as predictions of long-term world prices. Knowledge of the elasticities of supply in diverse activities which are possibilities for expansion would also be required.

Finally, the availability of more information about elasticity of response in agriculture and about the "shadow" rate of exchange are needed to make more precise estimates.

References

[1] Ahumada, Jorge, *En Vez de la Miseria*, Santiago, Edit. del Pacífico, Chile, 1958.

[2] Balassa, B., "Growth Strategies in Semi Industrial Countries," *Quart. J. Econ.* 84:24–47, Feb. 1970.

[3] ———, "Tariff Protection in Industrial Countries: An Evaluation," *J. Pol. Econ.* 73:573–594, Dec. 1965.

[4] ———, and D. Schydlowsky, "Effective Tariffs, Domestic Cost of Foreign Exchange, and the Equilibrium Exchange Rate," *J. Pol. Econ.* 76:348–360, May–June 1968.

[5] Corden, W. M., "The Structure of a Tariff System and the Effective Protective Rate," *J. Pol. Econ.* 74:221–237, June 1966.

[6] Davis, R. French, and C. Carrasco, "Cuatro Años de Experiencia con una Nueva Política del Tipo de Cambio," *Boletín Banco Central de Chile* 42:901–904, Aug. 1969.

[7] Echeverría, R., *Respuesta de los Productores Agrícolas ante Cambios en los Precios*, Santiago, ICIRA, 1967.

[8] FAO, *The State of Food and Agriculture*, various issues from 1947.

[9] Fontaine, E., "Evaluación Social de la Industria Azucarera Nacional," *Cuadernos de Economía*, No. 8, Santiago, 1966.

[10] ———, and F. Martinez, *Análisis de las Políticas de Fijación de Precios del Trigo y otros Cereales*, Dpto. Economía Agraria—Centro de Investigaciones Económicas (CIEUC), Santiago, Universidad Católica, 1970.

[11] Hachette, D., "Efecto de la Devaluación en la Distribución del Ingreso," *Cuadernos de Economía*, No. 10, p. 53, Santiago, December 1966.

[12] *Insumos Físicos de la Agricultura*, Corporación de Fomento and the Ministerio de Agricultura, Santiago, 1964.

[13] Johnson, H. G., "The Theory of Effective Protection and Tariffs," *Economica* 36:119–138, May 1969.

[14] Maizel, A., *Growth and Trade*, Cambridge, Cambridge University Press, 1970.

[15] Merrill, W. C., "Setting the Price of Peruvian Rice," *J. Farm Econ.* 49:389–402, May 1967.

[16] ODEPA (National Planning Office for Agriculture), *Plan Nacional de Desarrollo Agropecuario 1965–1980, Summary*, Santiago, Chile, 1968.

[17] Reca, L., *La Producción Agropecuaria y los Precios en la Región Pampeana 1924–1965*, Buenos Aires, Instituto Torcuato di Tella, 1968.

[18] Schultz, T. W., *Economic Growth and Agriculture*, New York, McGraw-Hill Book Company, 1968.

[19] Valdés, Alberto, "Comercio Exterior Agrícola en Chile," *Cuadernos de Economia*, No. 27, Santiago, Dec. 1972.

[20] Witherell, W. H., "A Comparison of the Determinants of Wool Production in the Six Leading Producing Countries 1949–65," *Am. J. Agr. Econ.* 51:138–158, Feb. 1969.

APPENDIX

Appendix Table 1. Farm imports from the U.S.A. under Program PL 480, 1955–1965 (millions of dollars)

Number of Agreement	1	2	3	4	5	6	Total
Title	IV	I	I	I	IV	I	
Year	1955	1956	June 1960	Nov. 1960	1962	1965	
1. Value cif[a] total imports dollars	5.0	34.6	3.1	28.9	21.0	19.7	112.8
2. Value cif agric. imports[b] dollars	5.0	27.6	0.7	23.7	19.5	19.8	96.3
Terms of payment:							
3. Number of years	5	30	20	20	20	20	—
4. Annual interest percent	3	3	3	3	3	3	—
5. Currency	dollars	escudos	escudos	escudos	dollars	escudos	
6. Credited to U.S. Embassy in Chile percent	20	20	30	20	0	30	—
7. Coolidge Amendment percent	0	0	25	0	0	15	—
8. Loan to the Chilean Government (percent of 2.) percent	80	80	45	80	100	55	—
Real cost in dollars							
9. Assumption A[c] $	5.0	5.5	.39	4.7	19.5	8.8	43.9
10. Assumption B $	5.0	12.1	.48	10.4	19.5	12.1	59.6

Sources: U. S. Embassy, Santiago, unpublished material; and *Revista El Campesino*, Santiago, June 1969, pp. 20–21.

[a] cif = cost/insurance/freight.

[b] The difference with line 1. corresponds to cotton imports, a product not cultivated in Chile.

[c] Assumption A: total loan to the Chilean Government classified as a donation.
Assumption B: 75 percent of the loan classified as a donation.

The true cost is estimated by considering as costs the items in 6. and 7., plus the portion of the loan to the Chilean Government not classified as a donation.

In the case of the Agreements under Title IV, 100 percent of the value of imports is classified as the real cost in dollars

Appendix Table 2. Estimation of the coefficient of imported inputs in cereals

	Share in average cost (1)	Percentage imported (2)	A_i^d Share in average cost represented by imported inputs (1×2) (3)	Ratio of domestic to international input prices at official exchange rate (4)	Ratio of input prices P_i^d/P_i (E^0 per dollar) (5)	P^d/P P_i^d/P_i (wheat) (6)	Share in imported inputs at world prices (7)
Operation Costs	%	%	%				%
Seed	16.5	0*	0	(1.17)	—	—	—
Fertilizers	15.5	9.4	1.5	1.40	16.6	0.63	1.0
Pesticides	0.02	9.4	0	2.37	28.2	0.37	—
Herbicides	0.3	9.4	0.02	2.30	27.4	0.38	—
Capital Goods							
Machinery	22.7	80.0	18.2	1.20	14.3	0.74	13.5
Equipment	8.3	80.0	6.6	1.10	13.5	0.78	5.2
Work Animals	5.2	0		—	—	—	—
Labor and others	31.2	0	0	—	—	—	—
Total	100.0		26.32	1.20**			19.7

Sources (the numbers 1, 2, 4, and 6 refer to column numbers in parentheses above):

1. Physical input/output ratios for 1961–62 from [12]; input/output price ratios for 1969–70 from [10].
2. From [11]. The imported component of the cost of capital represents the depreciation cost.
4. From [10, p. 60, Table IV]. At values prevailing in 1969–70; in that study this ratio is expressed by the equivalent to $P_i^d = P_i(1+t_i)$ at the official exchange rate.
6. $P^d = 795$ escudos per ton and $P =$ US $75.6 per ton cif, from [10, p. 60, Table IV).

* This value would be positive if other activities for which seed, eg., maize, is imported were analyzed.

** Weighted by relative values in column (7).

A Linear Programming Approach to Floodplain Land Use Planning in Urban Areas*

John C. Day

Floodplain land use management is a new approach to flood loss prevention which will complement engineering works and lead to more intelligent use and development of urban floodplain areas. Land use management may be structured as an optimization problem. Nonlinear or dynamic programming is inappropriate, and a linear programming assignment model is shown to be capable of identifying constrained efficiency combinations of spatial and temporal urban floodplain use, site elevation through land fill, and floodproofing of buildings. Sensitivity testing, however, is required because of possible nonlinearities.

The damaging effect of uncontrolled flooding is one of man's oldest land and water problems. Traditional methods for dealing with this natural threat have relied, for example, upon dams, levee systems, and floodwalls to regulate stream flow. However, engineering approaches are not capable of correcting all the physical and economic conditions that give rise to flood damage; alternatives to engineering structures exist. Floodplain land use management is one alternative approach that might be taken [15, 17, 18, 19]. Modern planning thus seeks better solutions to the age-old problem by encouraging intelligent use and development of floodprone land as well as control of floodwater.

A floodplain management plan bringing together regulation of land use through public administration and control of floodwater through engineering works is not easy to achieve. Difficulties occur at several levels: legal—what the law allows in the way of land use regulation; political—what can actually be accomplished in a particular flood hazard locale; administrative—who has the power to plan, implement, and enforce floodplain land use management practices; and last, technical—what difficulties relate to economic and engineering analysis of alternatives.

A basic problem in the design of comprehensive programs is the lack of suitable analytical methodology. James [10] was the first to work with a general methodology applicable to this particular type of problem. His approach is based upon an iterative routine for comparing discrete combinations of structural works and either urban or agricultural floodplain use. River areas are examined separately by reach for a series of time intervals. The value of land in urban vs. agricultural employment is used to compute the (opportunity) cost of land allocated to either one of the two choices. The objective of the routine is to minimize the cost of flood protection, residual flood loss, and the opportunity cost of land use. James was followed by Day [6] in the first effort to apply operations research techniques to the problem, the results of which are reported here. Much descriptive literature exists relating to the need for nonstructural planning [12, 18, 19, 21, 22] and to theoretical issues pertaining to economic criteria [13, 15, 20], but the work of James and of Day represents the current status of methodological research.

Floodplain management involves operating rules for the utilization of water and land resources. The design of structural works can be based upon optimal allocations of water to alternative uses with uses understood to include flood storage in reservoir or containment in channel through levees, etc. Similarly, a land use plan can be based upon optimal allocations of land to different employment. This view of the problem suggests that activity analysis may be a useful technique for making the required resource allocation decisions.

There is extensive literature dealing with optimization of water resource systems; however, the same cannot be said for urban land use planning, particularly in a floodplain context involving nonstructural measures. As a first step, research was initiated to try to determine if an optimizing model could be constructed which was capable of handling spatial

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and temporal land use assignments as well as site elevation and floodproofing of buildings. Hopefully, such a model could eventually include structural alternatives thereby yielding the multimeasure approach desired. The purpose of this paper is to summarize and evaluate a recursive linear programming approach to the land use management aspect of this problem.

The Programming Model and Its Planning Perspective

The model employed is a recursive (RLP) version of the linear programming assignment problem [11], in which specific urban land uses are allocated for a series of time intervals to alternative floodplain and upland locations. The land use assignment aspect of the approach has already been developed [9]. The distinctive character of this model is found both in explicit consideration of the fact that locational possibilities may be subject to periodic flooding and in the use of site elevation and floodproofing of individual buildings as alternatives in addition to locational decisions.[1]

The objective of the model is to identify the most economically efficient combination of spatial–temporal distribution of land use activities and employment of site elevation and floodproofing given a community's land use goals, resource endowment, expected growth, and existing flood risk. The objective function of the model reflects the efficiency goal with economic rent as a measure of the returns to land in alternative use. Other community goals, such as increased population, commercial and industrial expansion, and environmental quality control are also valid planning objectives, and a realistic normative model for land use should be capable of accommodating them. In the model tested growth forecasts and specified population density are expressed as constraints that must be satisfied. Other ends, such as the need to provide for greenbelts and parks, may also be achieved by setting them up as constraints; however, this was not done. An optimal spatial assignment of growth is made for a series of short time intervals spanning a planning horizon. Each land use activity in any location may or may not include site elevation and/or floodproofing. The extent to which these investment alternatives are included depends upon their cost and ability to reduce potential flood losses.

The Test Model

The community selected for testing the approach is an urban complex (estimated 1968 population 27,000) located in southeastern Minnesota. Flooding occurs from the Mississippi River and from three smaller tributaries. Approximately 1,150 acres of unoccupied land, almost all of which is subject to flooding, is under pressure for residential, commercial, and industrial development.[2] An enlarged levee system giving greater flood protection to the community, including the undeveloped but potentially productive floodplain, is under study by the U. S. Army Corps of Engineers.

Activities

Each activity in the model refers to a particular type of urban land use, either single family residential, commercial, or industrial, at a specific location, employing some level of both site elevation, and building floodproofing. Thus, each activity is denoted as $X_{ifp}^{k}(t)$ (see Appendix), which refers to the number of acres, X, devoted to each (ifp^k) combination where i identifies the specific type of land use making up the activity, k refers to its geographic location in the planning area, and f and p are indices indicating to what extent the activity employs site elevation and/or floodproofing. The residential category was divided into four subclasses based upon estimated property value.[3] Therefore six basic land use alternatives made up the activity set.

Site elevation possibilities are zero, two, four, six, and eight feet of land fill at each location. Floodproofing for residential structures involves only basements while for commercial and industrial buildings (without basements) it could range from zero to six feet high in two-feet increments.

The planning area (1,150 acres) was divided into 154 separate tracts averaging a little more than seven acres in size. The boundaries of each tract were established by reference to flood stage elevations and topographic maps and by estimates of the value of land in alternate uses. One set of boundaries thus consisted of hydrologic–topographic contours and the other of "economic" boundaries. Within each tract, productivity was therefore relatively constant for each type of use. The total number of tracts depends upon the size of the planning area and the economic and physical factors that determine land returns. Site elevation and floodproofing will either enhance, diminish, or have neutral effect on the productivity of each tract, depending upon the relationship between cost of such measures and the resulting reduction in potential flood losses.

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[1] Technical details of the model are summarized in [5]. A complete description of the model and its empirical application is contained in [6].

[2] To simplify this initial test, the model was limited to dealing with urban growth in vacant land only. Situations where one land use may replace another, as in an urban renewal context, are also possible with the present model, but to have included them in the model test would have extended the study beyond feasible bounds. This aspect of the problem, along with others, is being considered in current work.

[3] The basis for differentiating residential land use types has since been changed to one dealing with density of settlement as usually expressed in zoning classifications rather than value of property. The latter criterion for land use planning is highly suspect on legal grounds.

The combination of six land uses, 154 location possibilities, and alternative levels of fill and floodproofing resulted in a model having 12,320 possible activities. Since each activity represents *one* particular combination of all possible choices, the total number of activities is based upon the relation $i\cdot j\cdot f\cdot p$. Thus, there were 6,160 possible residential activities ($4\times 154\times 5\times 2$), plus the same number of commercial and industrial activities ($2\times 154\times 5\times 4$). It is worth noting that if no limits are placed upon the amount of fill or level of floodproofing that may be employed, one f or p level will dominate all others in which case the number of activity combinations is reduced to $i\cdot k\cdot 1\cdot 1$ or $i\cdot k$.

Constraints

Land Resources.—The physical bound on land resources was derived from the size (in acres) on each planning tract less the quantity of land assumed to be needed for public right–of–way. There were 154 land resource constraints, one for each planning tract. As solutions were generated through time, the right–hand–side–value for each tract was reduced by the quantity of land allocated to that location in previous time periods.

Land Use.—Upper and lower growth forecast bounds were estimated for each of the six basic land use activities. These bounds acted as the maximum and minimum number of units of each land use type that must find assignment somewhere in the community. There were 12 land use constraints that, together with the 154 for each tract, made a total of 167 constraints that had to be met.

Nonnegativity.—As usual, negative values for activity levels were precluded.

Feasibility conditions

Additional requirements were that site elevation and floodproofing be economically feasible investments and that (initially) all activity rents be positive (see Appendix, constraints 5, 6, and 7). Feasibility was determined through side calculations.

Input-output coefficients

Technical coefficients for land resources are all set at the value 1 indicating a 1 to 1 correspondence between resource input and activity output. Coefficients for the land use, or growth constraints, are based upon density of settlement for each type of activity.

The recursive programming format

The RLP formulation results in a separate LP problem for each of a sequence of short horizon planning periods. Parameters in the first problem in the sequence are derived from the actual stock of land available for settlement at time zero, from growth forecasts, and from desired land use density for the coming period. For all the following problems in the series, the state conditions are determined from optimal solutions for each previous problem and, as before, expected growth and density criteria for the upcoming period. Thus, as growth expected over different time periods is assigned to various locations, the stock of available land is reduced and the dynamic impact upon land rents is reflected in new objective function coefficients for the relevant time intervals.

Site elevation and floodproofing

Cost estimates for site elevation were based upon the quantity of fill material required to raise an acre of ground one foot in height and prices quoted by building contractors and material suppliers. For convenience, it was assumed that the cost of fill/acre–foot was constant as depth increased. Residential floodproofing was limited to the basement and is assumed to involve the application of waterproofing sealant to walls (inside and out) and floors, reinforced poured concrete walls and floors, corner anchoring to prevent building shift, and closure of all openings (i.e., no windows or doors, check valves on sewer lines, etc.). Costs were developed through interviews with building contractors. Commercial and industrial floodproofing costs were computed from data taken from Schaeffer's study [15] relating the height of protection with cost for representative estab-

Table 1. Capitalized costs of site elevation and floodproofing[a]

Activity	Assumed Probable Floor Area[b]	Depth of Land Fill (in feet)				Level of Floodproofing			
						Residential	Commercial & Industrial		
		2	4	6	8	Basement	2 ft.	4 ft.	6 ft.
		($)	($)	($)	($)	($)	($)	($)	($)
Residential Class 1	1,300 sq. ft.	1,220	2,440	3,660	4,880	1,600	—	—	—
Residential Class 2	2,000 sq. ft.	1,300	2,600	3,900	5,200	1,900	—	—	—
Residential Class 3	2,000 sq. ft.	1,300	2,600	3,900	5,200	2,200	—	—	—
Residential Class 4	2,700 sq. ft.	1,400	2,800	4,200	5,600	2,500	—	—	—
Commercial Class 5	14,500 sq. ft.	6,400	12,800	19,200	25,600	—	1,440	2,650	3,710
Industrial Class 6	14,500 sq. ft.	6,400	12,800	19,200	25,600	—	1,440	2,650	3,710

[a] Costs of site elevation and residential floodproofing are estimates taken from interviews with building contractors. Floodproofing costs for commercial and industrial activities are averages computed from data by Schaeffer [15, pp. 112–157].

[b] Assumed building areas for the four residential classes are estimates given by contractors for homes falling in each of the value categories. Floor areas for commercial and industrial classes are based upon the assumption that for any given acre of each of these uses, 2/3 of the acre would be in public streets and/or parking, trucking, and railroad use, and 1/3 would be devoted to building use.

lishments. Table 1 summarizes cost estimates used. Incremental comparisons of benefits and costs yield the feasible set of land use activities employing floodproofing and site elevation.

Object row coefficients

The coefficients in the objective function reflect the value per acre of land in alternative urban uses, with "uses" defined broadly to mean activities with various levels of fill and floodproofing. The concept of economic rent proved useful as a basis for computing the needed coefficients. Land rent can be defined as the sum of annual net returns to land resources discounted to their present value [8]. Rent will thus reflect the present value of the expected net benefits of land use including flood loss reductions stemming from structural flood control works as well as capitalized expected value of residual flood losses. The price of land as registered in a real estate transaction may be taken to be the present value of the new owners' expected net return generated by the land unit involved. There is then a correspondence between the economic rent a parcel earns and the price a buyer is willing to pay for it. Caveats are in order because of the imperfections of the land market and because of the difficulties associated with consumer surplus, of course. Nevertheless the use of land value as a proxy measure is substantiated in theory and in fact.[4]

Recent research [1, 2, 3, 14, 16] has demonstrated the use of urban land price data in statistical correlation and regression analysis to explain land value using independent variables relating to property and neighborhood characteristics as well as distances to central places of interest. These studies have met with mixed statistical success, but there is evidence to support the view that econometric approaches may be useful in this context. If the correlation between land use and land price can be quantified, along with other variables, it may be possible to derive *statistically* best estimates of the rent to land in alternative employment.

The hypothesis that statistical procedures using prices established in real estate transactions can yield acceptable estimates of land productivity remains to be tested, for time did not permit a land value study in the model test. In order to illustrate the kind of statistical work needed, a series of synthetic regression equations were developed from studies reported in the literature and from "spot" land sales occurring in the test community. These equations provided the basic land value data needed to construct the coefficients in the objective function.

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[4] Since the investment in public works will not be picked up in land rents, these costs will need to be given special handling to have them reflected in total net returns to a management plan. Two possibilities are to introduce them as a constant negative term in the objective function, or to distribute the costs to individual land use activities and include them in each objective function coefficient.

Flood losses and external effects associated with land use assignments required special handling. The extent to which expectations of loss are reflected in land values taken from a floodplain is very difficult to determine. Knowledge of the threat may differ among landowners which means that the real loss may be improperly accounted for in prices. Similarly, expectations of future flood protection may result in discounting of anticipated losses [18, 19]. Because of the inaccuracy of floodplain land values, price data were taken from nonfloodplain areas. Since these estimates did not reflect potential flood damages, the present value of the loss (based upon Corps of Engineer damage and flood frequency data) to each use in each floodplain location was subtracted from each value estimate. A similar approach was taken with respect to technological externalities. Numerous third party effects are associated with urban activity. To quantify all of them is unrealistic. Many are not unique to any particular land use assignment but are general effects arising with all urban settlement, e.g., traffic congestion, smoke, and noise. Some, however, might arise only during a flood and stem from floodplain development. For example, development in the floodplain may act as a barrier to flood flows, thereby raising flood stages upstream and velocity downstream and increasing loss over what it would have been otherwise.[5] Floodplain settlement may also increase public expenditures for repair and emergency measures, e.g., street damage, damage to sewer and water lines, and temporary dikes. These costs should, of course, be reflected in the net productivity estimates for floodplain assignments.

Determination of whether the general class of urban externality should be allowed for in a floodplain management problem requires additional study. To the extent that these problems arise irrespective of the decisions called for, viz., floodplain vs. nonfloodplain growth, and alternative locations plus site elevation and floodproofing within the floodplain, it is *conceivable* that they might be ignored as parameters in the floodplain management problem per se. Unfortunately any land use management program can be expected to have an effect upon the incidence of externalities if not their overall magnitude. The degree to which these often subtle yet pervasive impacts invite concern is not clear. What does seem obvious is that they cannot be too easily dismissed as unimportant in even this "special" problem area.

Interaction between land use activities raises another troublesome issue. Each object row coefficient is a function of the set of variables that influences the productivity of land. Many of these variables are related to the proximity of other land uses. Rents calculated on the basis of one spatial pattern of land use will change as new assignments are made by the model. This interdependence in objective function coefficients means that this assignment problem is non-linear [4, 11]; however, the size of the matrix indicates that LP algorithms currently may be the only feasible approach to the use of mathematical programming in this problem. Specialized sensitivity testing will therefore be required to ascertain just how extensive interaction is and how unstable given LP solutions are. This was not done in the present test.

Time constraints prevented a complete examination and empirical study of the externality issue and the interaction problem. For illustrative purposes, probable offsite public flood damage costs per acre of floodplain settlement (see Table 2) were, as before, first calculated as expected annual values, then converted to their equivalent present value and subtracted from estimates of "flood free rents" for each location. Other external costs and activity interaction were ignored. Object row coefficients are, thus, a blend of empirical and hypothetical indices of productivity and as such are only approximations but are judged to be sufficiently

Table 2. Representative public flood losses following a given flood event

Red Cross Expenses	\$ 4,270[a]
State Highway Patrol	50[a]
Evacuation and Rehabilitation	2,700[a]
Village Damage (streets, services, etc.)	65,092[b]
Clean-up Expenses	11,860[c]
Total	\$83,972
Total per acre flooded	\$ 2,660

[a] U. S. Army Corps of Engineers.
[b] Office of Civil Defense Funds Administered under P.L. 81-875.
Department of Public Welfare.

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[5] Calculation of such added costs can be facilitated through use of computer programming of backwater profiles (see [7]).

accurate (certainly relative to each other) for testing the basic aspects of the model.

Whenever levels of site elevation and floodproofing could not meet the test of incremental economic feasibility, that particular land use alternative was removed from the activity list. Initially the same was done for all activities incrementally feasible in terms of site elevation and floodproofing but still not capable of yielding positive overall returns because of high residual flood loss (see Appendix, constraint 7). It was later found necessary to include some floodplain locations generating negative rents[6] in order to satisfy the growth constraints.

The Programmed Land Use Plan

The solution to the problem tested covers the periods 1969–1975 and 1976–1980[7] and specifies temporal and spatial patterns of residential, commercial, and industrial land use, the level of site elevation and floodproofing employed, and the total quantity (in acres) of each land use type that maximizes the value of the objective function (see Fig. 1). The value of the objective function for 1975 is $2,072,585; for 1980 it is $1,522,344. In the mathematical sense, these values represent an empirical estimate of the total rent to land employed in the optimal solution.[8] Care must be taken, however, not to interpret solution values as a measure of benefits (either net or gross) stemming to the local and/or national economy. Such benefits can only be computed net of foregone development elsewhere in the local area or the nation, and net of what would have happened in the absence of the floodplain management program.

Spatial assignments

Table 3 contains information pertaining to forecasted growth and optimal land use allocations. Figure 1 reveals that commercial growth is predominantly directed to locations adjacent to main traffic intersections, and industrial settlement occurs close to existing industrial parks. However, new residential activity is not always located adjacent to existing developments so that extension of in-place services would not be possible. Given population growth, the shortage of flood free land forces some residential activities into negative rent earning locations. Use of higher population density coefficients in the constraints would tend to eliminate this problem; however, it raises interesting questions, viz., whether the planning area should be enlarged to increase the stock of flood free land, whether adversely located activities should receive a cash subsidy to compensate for their losses or be provided flood protection (site elevation, floodproofing, flood control) at public expense, and/or whether growth should be limited.

Optimal site elevation and floodproofing

The optimal plan for both time periods indicates site elevation is not an optimal policy because of the high costs in relation to damages prevented (constraint 5). Floodproofing, on the other hand, was often more profitable (incrementally) for low levels of protection than site elevation, but the high residual damages resulting from overtopping the floodproofed level eliminated activities with low levels of floodproofing from consideration in the model (constraint 7). A high level of floodproofing is a more beneficial approach with some 28 percent

Table 3. Land use forecasts, optimal land assignments

Land Use Class	Forecasted Land Requirements[a] (acres)		Optimal Land Assignments (acres)	
	(1975)	(1980)	(1975)	(1980)
Residential 1	21–82	19–61	82	19
2	21–82	19–61	82	19
3	13–43	10–23	21	10
4	4–12	3–9	4	3
Commercial	18–36	15–30	36	30
Industrial	30–53	25–45	53	45

[a] Maximum and minimum forecast.

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[6] Negative economic rents arise because of the manner in which activity coefficients were computed for locations within the floodplain. Each coefficient is a forecast of the rent that presently vacant locations could earn in urban employment. The basis of each forecast is the productivity of comparable, but *flood free* land. Introducing potential losses reduces rents, and in some cases the loss exceeds the "flood free rents." Reflecting this situation, the coefficients for some activities are therefore negative. As the demand for land increases, negative rents may become positive despite potential losses.

[7] This time horizon is much shorter than necessary, but it is long enough to illustrate the division into shorter planning periods.

[8] This statement should be qualified. Auxiliary computer output that accompanies optimal solutions indicates that a few other land use activities could replace some of those listed in the primal optimal without decreasing the value of the objective function. Thus the listed optimal is not a unique solution. However, since these other alternatives were very small in number, for all practical purposes the above statement is correct.

of the land area devoted to this alternative. The benefit–cost ratio for the optimal floodproofing program was 12:1.

Sensitivity analysis

Sequential decision-making through recursive programming helps to reduce some of the detrimental effects of uncertainty but does not eliminate these problems. The parameters in each model are subject to estimation errors and the variability associated with random and stochastic events.[9] Several sensitivity studies were conducted, involving changes in right–hand–side–values, object row coefficients, costs of

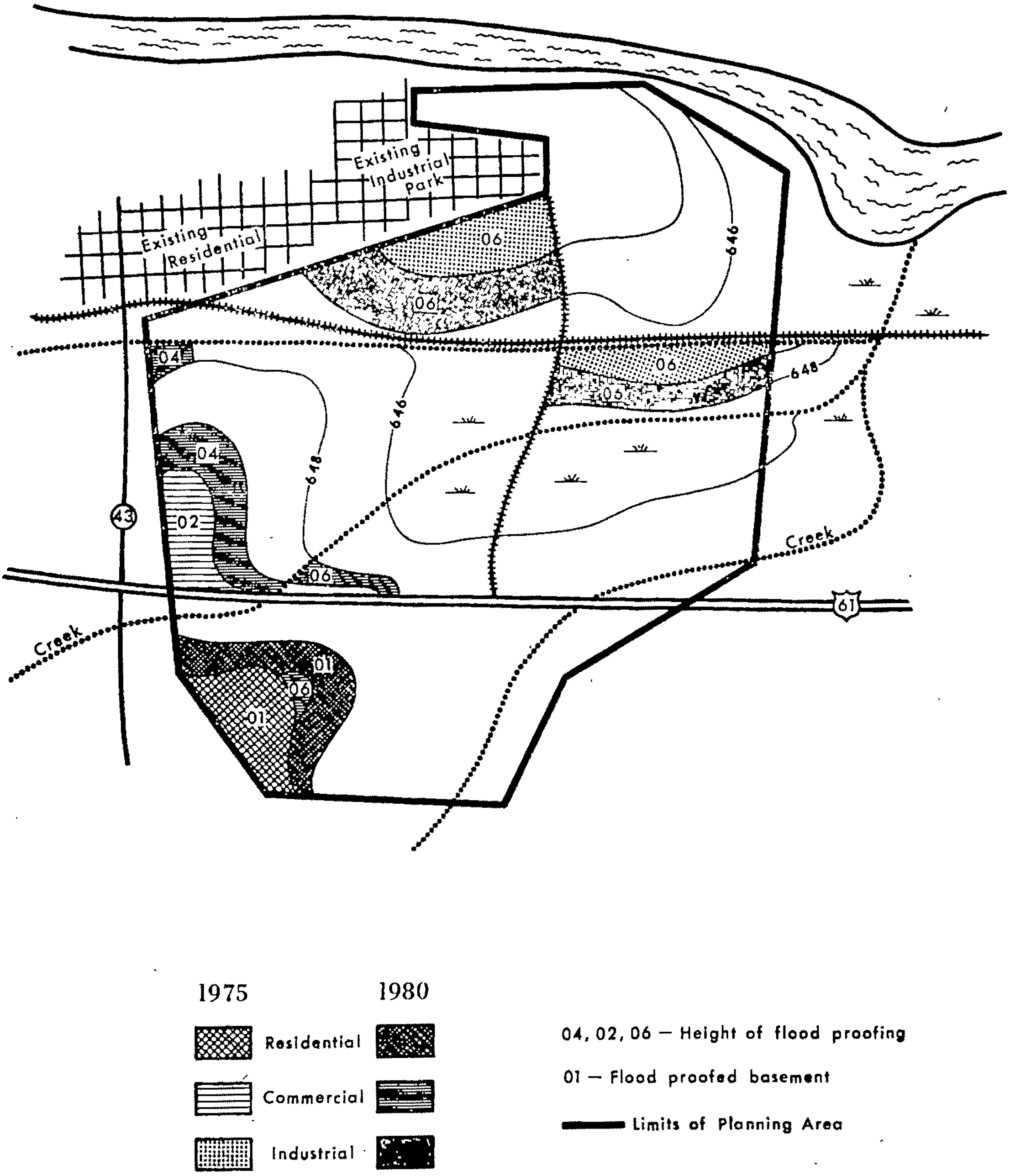

Figure 1. Programmed land use development (schematic)

floodproofing and site elevation, and degree of flood hazard, in order to examine the stability of the solution.[10]

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[9] The variability associated with stochastic streamflow is reflected in expected value of flood losses computed on the basis of the probability of occurrence of flood events.

Estimates of growth set at mean forecast value did not change the solution makeup to any great extent. When objective function coefficients were varied by assumed standard errors of regression, solution makeup remained fairly stable due to the large differences in rents between the several land use categories. Doubling floodproofing costs eliminated this alternative altogether, while a 50 percent reduction of site elevation costs brought this activity in. Assuming absence of flood threat led to a much more intensive use of the floodplain increasing total rents to land by 135 percent. With no protection allowed (i.e., no site elevation and floodproofing), greater dispersion of settlement occurred, and total rents fell by 25 percent with the floodplain much less densely occupied.

Concluding Remarks

The principal conclusion at this stage of research is that it is possible to construct an operations research model accommodating the floodplain management alternatives considered, but a number of issues need to be considered before the usefulness of such an approach can be certain. The spatial planning aspect has considerable merit since a need exists for determining whether it is "better" to have settlement in the floodplain or out of it, and the timing of such growth. Floodplains can be very productive locations despite flood frequency, hence a device which weighs the costs and returns associated with these sites can be helpful to planning. Site elevation and floodproofing were handled quite easily although existing data pertaining to the cost and effectiveness of alternative floodproofing practices is limited.

A recursive linear programming format has distinct advantages over a single stage LP for an entire planning horizon for several reasons. By dividing the horizon into shorter intervals, information regarding the timing of probable community growth may be utilized for the staging of management plans through time. The use of planning periods also permits greater advantage to be taken of the more accurate data of the near future and immediate plans to be formulated with relative confidence. Solutions for distant time periods should be regarded as tentative guidelines, and as time unfolds, input to the model can be adjusted to reflect new or unanticipated conditions. Hence, accuracy and flexibility are improved by the sequentially linked system of modeling. In addition, recursive programming suggests a way of coping with land use interaction that affects objective function coefficients because rents in time period $(t+1)$ can be adjusted for interdependencies appearing as a result of assignments made in (t). Unfortunately, separate optimization for each time interval in the series will not necessarily lead to an optimal for the entire horizon. Dynamic programming is the ideal approach to this class of problem, but the many state variables involved render that method currently infeasible.

Several other positive observations can be made on the basis of the work performed: (1) economic rent attributable to location is a useful concept for determining the combined efficiency benefits of structural and nonstructural flood damage control practices; (2) LP matrices for this type of problem, although likely to be quite large, are also very sparse (1 percent dense in this study) so that computation time is short; (3) residual flood losses that remain following a management plan can be easily identified thereby providing the information needed to establish flood insurance premiums under the terms of the federal flood insurance program.

Two major problems remain and require additional study. First, using market value as an efficiency index of land productivity in urban employment is straightforward, but the accuracy with which empirical estimates of property value can be made is uncertain. Current research effort seeks to test the precision obtainable with statistical correlation and regression, and to determine the relationship between residential zoning, or density of settlement, and property value. In any event, the usefulness of an efficiency objective function depends upon the importance given to economic considerations and how well other objectives are accommodated in the model. Second, the nature of the model, that is, the way in which activities are defined (multiplicative combinations of land use, alternate locations, and various levels of site elevation and floodproofing) is such that rather large size assignment problems are to be expected. This fact, together with the possible interaction arising between assignments, raises computational difficulties.

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[10] Parametric programming can be very useful in this regard. Due to technical difficulties with our computer, we were not able to complete this phase of the model test. As an approximation to parametric work, a limited number of arbitrary parameter ranges were chosen and each LP rerun.

In conclusion, optimizing approaches apparently have the potential for improving flood damage control planning. With additional conceptual and empirical work and with continuing improvements in computer technology, it is not too sanguine to expect that potential to be realized.

References

[1] BOXLEY, R. F., *The Relationship Between Land Values and Flood Risk in the Wabash River Basin*, U.S. Army Corps of Engineers Institute of Water Resources Rep. 69-4, Washington, D.C., 1969.

[2] BRIGHAM, EUGENE F., "The Determinants of Residential Land Values," *Land Econ.* 4:325–334, Nov. 1965.

[3] CLONTS, HOWARD A., "Influence of Urbanization on Land Values at the Urban Periphery," *Land Econ.* 4:412–422, Nov. 1970.

[4] DAVIS, OTTO A., AND ANDREW B. WHINSTON, "The Economics of Complex Systems: The Case of Municipal Zoning," *Kyklos* 17:419–445, 1964.

[5] DAY, JOHN C., "A Recursive Programming Model for Nonstructural Flood Damage Control," *Water Resources Research* 6:1262–1271, Oct. 1970.

[6] ———, *A Recursive Programming Model for the Selection of Non-structural Floodplain Management Systems*, unpublished Ph.D. thesis, University of Wisconsin-Madison, 1969.

[7] DOUGAL, M. O., AND JAMES SHEARMAN, "Computer Program for Determining Water Surface Profiles, WSPPI," *Ciras*, Ames, Iowa State Univ. Press, 1965.

[8] GAFFNEY, M., "Ground Rent and the Allocation of Land Among Firms," in *Rent Theory, Problems and Practices*, North Central Regional Res. Pub. 139:30–49, 1962.

[9] HERBERT, JOHN D., AND BENJAMIN H. STEVENS, "A Model for Distribution of Residential Activity in Urban Areas," *J. of Regional Sci.* 2:21–36, 1960.

[10] JAMES, L. DOUGLAS, "Economic Analysis of Alternative Flood Control Measures," *Water Resources Research* 3:333–343, 1967.

[11] KOOPMANS, TJALLING C., AND MARTIN J. BECKMANN, "Assignment Problems and the Location of Economic Activity," *Econometrica* 25:53–76, Jan. 1957.

[12] PHIPPEN, GEORGE R., "A New Course to Ararat," *Water Spectrum* Summer 1971.

[13] RENSHAW, EDWARD F., "The Relationship Between Flood Losses and Flood Control Benefits," in *Papers on Flood Problems*, ed. Gilbert F. White, Dept. of Geog. Res. Paper 65, U. of Chicago, 1960.

[14] RIDKER, RONALD G., AND JOHN A. HENNING, "The Determinants of Residential Property Values with Special Reference for Air Pollution," *Rev. of Econ. and Stat.* 2:246–257, May 1967.

[15] SHEAFFER, J. R., "Flood Proofing: An Element in a Flood Damage Reduction Program," in *Papers on Flood Problems*, ed. Gilbert F. White, Dept. of Geog. Res. Paper 65, U. of Chicago, 1960.

[16] STRUYK, R. J., ed., *Agricultural Flood Control Benefits and Land Values*, U.S. Army Corps of Engineers Inst. for Wat. Resources Rep. 71-3, Washington, D.C., 1971.

[17] U. S. Army Corps of Engineers, Office of the Chief of Engineers, *Survey Investigations and Reports*, Circular 1120-2-40, Washington, D.C., 1968.

[18] U. S. Congress, *A Unified National Program for Managing Flood Losses*, House Doc. 465, 89th Cong., 2nd Sess., 1966.

[19] U. S. Congress, *Policies, Standards and Procedures in Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources*, Senate Doc. 97, 87th Cong., 2nd Sess., 1962.

[20] WENDT, PAUL F., "Theory of Urban Land Values," *Land Econ.* 33:228–240, Aug. 1957.

[21] WHITE, GILBERT F., *Choice of Adjustment to Floods*, Dept. of Geog. Res. Paper 93, U. of Chicago, 1964.

[22] WHITE, GILBERT F., ed., *Papers on Flood Problems*, Dept. of Geog. Res. Paper 70, U. of Chicago, 1961.

Appendix

The land use management model may be written mathematically as follows:

$$\text{Max } Z = \sum_{kifp} \Pi_{ifp}^k(t) X_{ifp}^k(t) \qquad t = 1 \cdots T$$

Subject to

Constraint 1

$$\sum_{ifp} X_{ifp}^k(t) \leq A^k(t) \qquad \begin{array}{l} t = 1 \cdots T \\ k = 1 \cdots K \end{array}$$

Constraint 2

$$\sum_{kfp} d_i^k(t) X_{ifp}^k(t) \leq PU_i \qquad \begin{array}{l} t = 1 \cdots T \\ i = 1 \cdots I \end{array}$$

Constraint 3

$$\sum_{kfp} d_i^k(t) X_{ifp}^k(t) \geq PL_i \qquad \begin{array}{l} t = 1 \cdots T \\ i = 1 \cdots I \end{array}$$

Constraint 4

$$X_{ifp}^k(t) \geq 0 \qquad \text{for all } i, k, f, p, t$$

Constraint 5

$$ICF_{if}^k(t) \leq [\Delta TFL_{if}^k(t)] \qquad \text{for all } i, k, t, f > 0$$

Constraint 6

$$ICP_{ip}^k(t) \leq [\Delta FLI_{ifp}^k(t)] \qquad \text{for all } i, k, f, t, p > 0$$

Constraint 7

$$\Pi_{ifp}^k(t) \geq 0 \qquad \text{for all } i, k, f, p, t$$

where:

$\Pi_{ifp}^k(t)$ = estimated economic productivity per acre of the kth unit of land in the (ifp) employment;

$X_{ifp}^k(t)$ = number of acres devoted to the (ifp^k) activity;

k = specific geographic location;

i = land use which may be allocated to each of the kth locations;

f = index denoting the presence or absence of landfill: $f=0$, no landfill; $f>0$, landfill to depth indicated by value assigned to f;

p = index denoting the presence or absence of floodproofing; $p=0$, no floodproofing; $p>0$, floodproofing to height indicated by value assigned to p;

t = time period

$d_i^k(t)$ = coefficient indicating the desired density of the ith use in the kth location;

$A^k(t)$ = number of acres in the kth location;

$PU_i(t)$ = upper limit of expected growth of the ith land use category;

$PL_i(t)$ = lower limit of expected growth of the ith land use category;

$ICF_{if}^k(t)$ = present value of the incremental cost of landfill for the ith land use to the f level;

$ICP_{ip}^k(t)$ = present value of the incremental cost of floodproofing an ith land use to the p level;

$\Delta TFL_{if}^k(t)$ = present value of the change in flood loss attributable to the (if^k) land use as land fill is incrementally increased;

$\Delta FLI_{ifp}^k(t)$ = present value of the change in flood loss to the (ifp^k) activity as floodproofing is incrementally increased.

Quadratic Programming for Least-Cost Feed Formulations under Probabilistic Protein Constraints*

JOYCE T. CHEN

This paper shows how a stochastic programming model for least-cost feed formulations under a probabilistic protein constraint and other linear restrictions can be solved by using an iterative quadratic programming technique. As the least-cost plan for a given probability level must be E-σ efficient, the result thus obtained is optimal.

A MAJOR problem associated with the application of conventional linear programming in determining the least-cost feed mixture which satisfies certain specific nutritive and nonnutritive requirements is the risk associated with the nutritive content of each ingredient. Risk arises because the nutritive content can vary considerably from one batch of ingredients to another.

When a normally distributed random element exists, and when its variability is ignored and only its mean is used in the programming model, the resulting mixture will fail to meet the guaranteed nutrient content 50 percent of the time. A concept of probabilistic constraints (i.e., chance-constraints [1, 2, 5]) can be used to raise the probability of meeting the specified requirements from this conventional 50 percent level to a desired higher level while retaining cost-minimizing properties of the model. This is important when a minimum content of some nutritive element is guaranteed by the feed manufacturer as is often the case with the protein content in a feed mix.

Although protein is not the only stochastic restraint, it is frequently the limiting factor in the rations fed to livestock [3], and protein supplements are expensive feeds.[1] Protein affects almost every body function. Hence it is necessary to prepare a livestock ration that contains a minimum protein content at a rate considerably higher than 50 percent of the time. The objectives of this paper are to test a method of determining the least expensive combination of livestock feed meeting a certain minimum probabilistic protein requirement and to test the implications of this probabilistic requirement in terms of total cost.

A nonlinear deterministic equivalent equation (a function of the mean and variance of the random element) for the stated probabilistic restraint can be derived. The problem, therefore, can be specified with a linear objective function and quadratic constraints. It will be shown that a problem of this type can be solved by using an iterative quadratic programming technique. The procedure derived is based on the facts that it often costs more to produce a mixture with higher attainable probability of success in meeting the required minimum protein content, and for a given cost the mixture with the highest attainable probability of success must be E-σ efficient, where E stands for the mean protein content in the mixture and σ stands for its standard deviation.

Stochastic Programming Models

Given certainty in estimates of cost and nutrient content for each ingredient, the problem can be formulated as a standard linear programming model. Solution of the model minimizes the cost for the final mixture so that the specified nutrient requirements are satisfied. But the nutrient content of ingredients is likely not known with certainty. To prepare a livestock ration that contains a minimum percentage weight of protein at a specified level of probability, a chance constrained programming model is formulated as follows:

Minimize $c'x$

subject to

(1) $\quad \text{Prob}\ (p'x \geq d) \geq \beta,$

(2) $\quad Ax \geq b,$

(3) $\quad x \geq 0.$

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[1] Moreover, cost of soybean meal and other high protein feeds are expected to be considerably higher in the near future as is stated in the *Illinois Farm Outlook*, Sept. 1971.

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Where

x = an $(nx1)$ vector of decision variables concerning the quantity of each of n possible ingredients in the final mix;
c = the corresponding $(nx1)$ vector of cost coefficients;
p = an $(nx1)$ vector of stochastic protein content in the ingredients;
d = the guaranteed minimum protein percentage in the mixture;
β = the required minimum probability of success;
A = an (mxn) matrix, and b is an $(mx1)$ vector of the other nutritive and nonnutritive requirements.

If vector p is normally distributed with mean vector $\bar{p}$ and dispersion matrix W, the nonlinear deterministic equivalent for equation (1) is

$$\bar{p}'x - \underline{q}(x'Wx)^{1/2} \geq d, \tag{4}$$[2]

where $-\underline{q}$ is $(1-\beta)$ Fractile of $N(0, 1)$. Thus $-\underline{q} \leq 0$, since a probability of success that exceeds 50 percent is the goal.

If the distribution of vector p is not approximately normal or if totally unknown, equation (1) can still be transformed into a deterministic constraint equivalent to that shown in equation (4). However, in this case $-\underline{q} = -(1-\beta)^{-1/2}$ is obtained from the Chebyshev's approximation and is much larger than that of the normal deviate.[3]

Accordingly, to raise the probability of success to more than 50 percent, the mean protein requirement should be adjusted by its variance in the final mix. In other words, the deterministic equivalent of the probabilistic protein constraint shows that the mean protein content of a feed mix is not a good measure for the optimality criterion. Instead, mean and variance both should be considered simultaneously within the program. The conventional least-cost linear programming problem is therefore turned into a nonlinear programming model with a linear objective function, and one nonlinear constraint among a number of linear restrictions.

Alternative Methods of Solution

When the nonlinear constraint, equation (4), replaces the probabilistic constraint, the chance-constrained programming model is converted into a deterministic nonlinear programming model. Zoutendijk has provided a method for finding an optimal solution [11, 12]. Zoutendijk's method has been simplified by Van De Panne and Popp [10] to deal with one probabilistic restraint. However, the method is iterative, and heuristic judgment is needed. Care must be taken in each step of computation so that the feasible directions and optimal lengths of movements are properly derived. Otherwise, convergence may be very slow or even nonexistent.

As a consequence, Rahman and Bender [9] have recommended a method to linearize the nonlinear constraint, equation (4), so that the linear programming code is applicable. More specifically, they have proposed the linearized equation,

$$\bar{p}'x - q \sum_{j} (x_j\sigma_j) \geq d, \tag{5}$$

for the stochastic linear programming model, where σ_j is the standard deviation of p_j, the protein content of the jth ingredient. Thus, as Rahman and Bender themselves have noticed, the method they have proposed is equivalent to the traditional method of downgrading the mean nutrient contained in each ingredient to allow for a certain safety margin [8].

The linearized equation has assumed the protein content to be perfectly correlated among ingredients. That is, the correlation coefficient between p_j and p_k is 1.0, $j \neq k$, for all j and k, since

$$\left(\sum_{j} x_j\sigma_j\right)^2 = \sum_{j} x_j^2\sigma_j^2 + \sum_{j}\sum_{\substack{k \\ j\neq k}} x_jx_k\sigma_j\sigma_k.$$

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[2] Because if $p'x \sim N(\bar{p}'x, x'Wx)$, then

$$\text{Prob}\left[p'x \geq \bar{p}'x + F^{-1}(1-\beta)(x'Wx)^{1/2}\right] = \beta,$$

or

$$\text{Prob}\left[p'x > \bar{p}'x - F^{-1}(\beta)(x'Wx)^{1/2}\right] \quad \beta.$$

[3] Since Prob $(p'x \geq d) \geq \beta$, if and only if Prob $(p'x \leq d) \leq 1-\beta$, where

$$\begin{aligned}\text{Prob}\,(p'x \leq d) &= \text{Prob}\,(\bar{p}'x - p'x \geq \bar{p}'x - d)\\ &\leq \text{Prob}\,(|\bar{p}'xp'x| \geq \bar{p}'x - d)\\ &\leq \frac{x'Wx}{(\bar{p}'x - d)^2} \quad \text{(Chebyshev's Inequality)}.\end{aligned}$$

Thus if

$$\frac{x'Wx}{(\bar{p}'x - d)^2} \leq 1 - \beta,$$

or if

$$\bar{p}'x - (1-\beta)^{-1/2}(x'Wx)^{1/2} \geq d,$$

then

$$\text{Prob}\,(p'x \geq d) \geq \beta.$$

That is,

$$\text{Prob}\left[p'x \geq \underline{p}'x - (1-\beta)^{-1/2}(x'Wx)^{1/2}\right] \geq \beta.$$

In contrast, the protein content of the ingredients is more likely to be independent; that is, $x'Wx = \sum_j x_j^2\sigma_j^2$. Thus $\sum_j (x_j\sigma_j)$ overestimates the actual total standard deviation of protein contained in the final mixture. The actual probability of meeting the required minimum protein content would generally be more than the specified level, β [9, p. 615]. Moreover, as a consequence of the unduly restrictive assumption of equation (5), parametric linear programming fails to account for the true relationships between random protein contents in each ingredient. The iterated result for the desired level of probability of success is likely to deviate greatly from the true optimal nonlinear programming result.[4]

A Revised Stochastic Programming Model

When one nutritive constraint is considered probabilistic, an optimal feed mix may be selected on the basis of unit cost and its associated probability of success in meeting a minimum level of this specific nutritive requirement. When other things are equal, it often costs more to produce the mixture with a higher attainable probability of success. Therefore a revised stochastic programming problem can be specified to maximize the probability of success, such that the cost and other linear inequality restrictions are satisfied:

$$\begin{aligned} \text{Maximize} \quad & \text{Prob}\,(p'x \geq d) \\ \text{subject to} \quad & c'x \leq k, \\ & Ax \geq b, \\ & x \geq 0. \end{aligned}$$

If an optimal solution of this type of problem can be easily derived, one can parametrize k uniformly over a large range within which the desired level of success, β, may exist. The result is optimal with respect to the original stochastic programming model.

Discussion of the Model

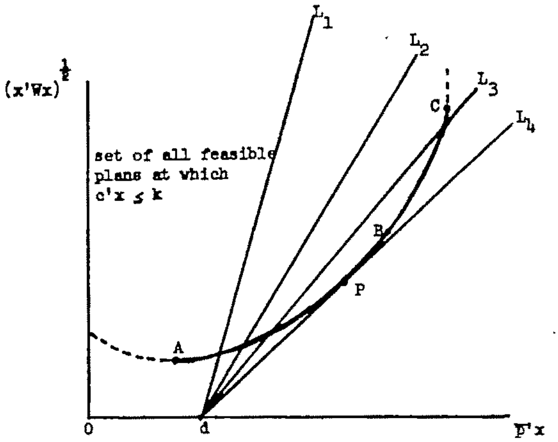

Figure 1. The highest-probability-of-success plan under a given cost restriction level k

The nonlinear deterministic equivalent equation (4) for the probabilistic protein constraint is a function of mean and variance of protein contained in the final mix. Thus an optimal mix for the above revised stochastic programming problem must be mean-standard deviation (E-σ) efficient. Analogous to the efficient portfolio, defined by Markowitz [6], an efficient feed mix can be defined as follows: for the feed mix of a given unit cost, it is impossible to change the ingredient combination to obtain a greater mean protein content without incurring a greater standard deviation; it is impossible to obtain a smaller standard deviation without reducing the mean protein content.

A quadratic programming (QP) model can be applied to obtain a series of efficient feed mixes under any given cost restriction. The model is constructed as follows:

$$\begin{aligned} \text{Maximize} \quad & \bar{p}'x - \alpha x'Wx \quad (\text{for } \alpha = 0 \text{ to } +\infty) \\ \text{subject to} \quad & c'x \leq k, \\ & Ax \geq b, \\ & x \geq 0. \end{aligned}$$

Curve ABC in Figure 1 defines all efficient E-σ combinations. Point C is identical to the conventional linear programming results which identify the combination with the highest mean protein attainable when cost is restricted to be no greater than k dollar per ton.

Concern centers on the mix with the highest probability of success, as indicated in the revised stochastic programming model. Hence one and only one point along the ABC boundary is pertinent to the present problem, and the location of this point is now examined.

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[4] Although parametric linear programming for $\underline{q}$ over an appropriate range generates a ration that does satisfy the desired level of probability of success, the mixture is likely to be nonoptimal in terms of the original stochastic programming problem. Cost is likely to be greater than the minimum attainable for this ration cost because the solution thus obtained minimizes $(\sum_j x_j\sigma_j)^2$ rather than the true measurement of total variance $\sum_j (x_j\sigma_j)^2$, for any given ration cost and mean protein content restrictions. The solution is therefore less efficient in terms of the mean–standard deviation criterion which will be discussed later.

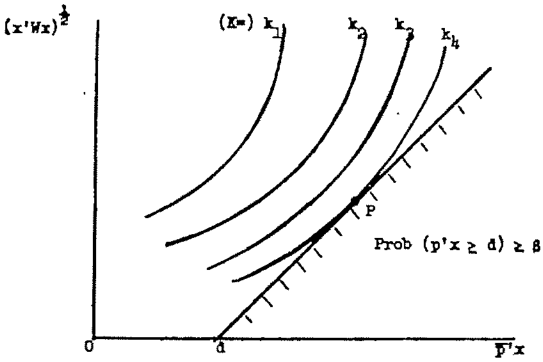

Figure 2. **The least-cost plan under a given probability restriction level β**

The deterministic equivalent equation (4) implies that the set of iso-probability-of-success curves form a set of linear rays drawn from point d on the horizontal axis. d is the specified minimum percentage weight of protein per ton of feed in the final mixture. To maximize Prob $(p'x \geq d)$ is equivalent to minimize

$$1/q = \frac{(x'Wx)^{1/2}}{\bar{p}'x - d}$$

where $1/q$, the slope of L in Figure 1, is a proxy for the probability of meeting the guaranteed protein content. Accordingly, point P, at which L_4 is tangent to the E-σ boundary, is the optimal solution point for the revised problem.

The larger the value of d, the higher the tangent point P. Thus the point of the highest probability level tends to move upward along the E-σ boundary and ultimately arrives at point C in Figure 1, the deterministic linear programming solution.

A less risky situation associated with the ingredient protein content may also arise and leads to a very flat E-σ boundary. Such a situation would imply the magnitude of risk involved in the conventional linear programming result is relatively small in comparison with risks involved at other points along the boundary.

When the risk involved in the conventional linear programming result is relatively small in comparison with other efficient points at which risk is considered, and/or when the required protein level, d, is relatively large in comparison with the maximum mean protein attainable under the given cost restraint, ignoring risk, then point C in Figure 1 is probably the most acceptable feed mixture, even if risk is considered.

In regard to the original stochastic programming problem, at this point only one restraint need be considered as probabilistic, and a standard quadratic programming model and a nonlinear deterministic equivalent equation can be derived. For each cost restriction k, there is a feasibility E-σ boundary and for any $\bar{p}'x$ there is a maximum $(x'Wx)^{1/2}$ that is consistent with the given probability restriction level β. The problem can therefore be represented in Figure 2.

It is also economically meaningful to combine Figure 1 and Figure 2 and get the set of "efficient" k, β plans, the least cost plans for set of probability levels. The curve composed of the efficient k, β plans can be defined as the least-cost expansion curve: the curve $P_1P_2P_3P_4$ in Figure 3. For each point along this curve, a higher probability of meeting the nutrient restraint cannot be obtained without raising cost, or a lower cost without reducing the probability of satisfying the restraint. Thus the least-cost formulation for a given probability level must be the plan that corresponds to a point somewhere along this expansion curve. For example, the formulation corresponding to P_i, for $i=1$, 2, 3, and 4 in Figure 3, is the optimal formulation for a required probability level β_i, for $i=1$, 2, 3, and 4, respectively.[5]

The Computational Procedure

It has already been illustrated how the probability of success can be incorporated with the more traditional optimizing objective associated with a mean and variance model such as quadratic programming. A model so modified can be solved easily for the size of problem common in feed formulations. Thus the iterative quadratic programming technique is convenient for solving for the least-cost feed mixture under conditions of a probabilistic protein constraint and other linear restrictions.

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[5] It should be clear at this point that if the solution E-σ boundary for any ration cost is less efficient than that of QP solutions, this less efficient boundary will be located to the left of curve ABC in Figure 1 and intersects it at point C. Thus, unless L_i is tangent to curve ABC at point C, the maximum attainable level of probability along the less efficient boundary is smaller than that along curve ABC; the most acceptable plans along these two boundaries are different from each other. As a consequence, unless point C_i represents the highest probability-of-success plan for any level of ration cost, and thus the curve which connects these points represents the least-cost expansion path, any solution generated by other programming methods not taking variance of protein content explicitly into account is likely to be nonoptimal. It is therefore obvious that the solution generated by Rahman and Bender's parametric LP method [9] is likely to deviate greatly from the optimal solution. In their example problem, the conventional LP solutions which maximize means, ignoring risk, constitute the true least-cost expansion path.

The suggested procedure can be modified and summarized as follows:

I. Linear Programming Problem

i. Solve the linear programming problem:

$$\begin{aligned} &\text{Minimize} && c'x \\ &\text{subject to} && p'x \geq d, \\ &&& Ax \geq b, \\ &&& x \geq 0. \end{aligned}$$

ii. Determine where (a) or (b) applies:

$$\text{(a)}\quad F\left[\frac{p'x^o - d}{(x^{o\prime}Wx^o)^{1/2}}\right] \geq \beta,$$

$$\text{(b)}\quad F\left[\frac{p'x^o - d}{(x'Wx^o)^{1/2}}\right] < \beta.$$ [6]

If case (a) applies, stop the calculation since the optimal result is obtained. Note that this case seldom happens for the present feed formulation problem.

If case (b) applies, go to step II.

II. Quadratic Programming Problem

i. Solve and record the results at every basis change for the parametric quadratic programming problem:

$$\begin{aligned} &\text{Maximize} && p'x - \alpha(x'Wx) \quad (\text{for } \alpha = 0 \text{ to } +\infty) \\ &\text{subject to} && c'x \leq k, \\ &&& Ax \geq b, \\ &&& x \geq 0, \end{aligned}$$

with $k = c'x^o + 1.00$ and where x^o is the result of the above linear programming model.

ii. Calculate the highest attainable q value, that is, the highest $(p'x^o - d)/(x^{o\prime}Wx^o)^{1/2}$ value, along the resulting E-σ boundary. Note that if this value should occur between two consecutive critical turning points of the above parametric quadratic programming, linear interpolations can be applied to the optimal compositions at these two points.

iii. Determine the probability of success implied by this highest q value and then decide whether step II should be repeated. If so, judge what value of k should be applied next to accelerate convergence to the desired result.

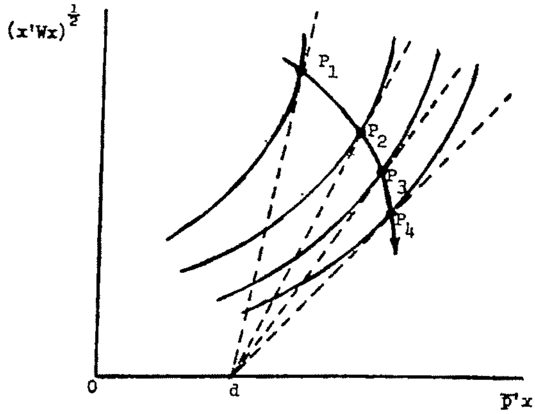

Figure 3. The least-cost expansion curve

Between each step of computation, judgment is necessary with respect to the value of k to obtain a fast convergence. An initial linear programming formulation is suggested to supply an idea about the appropriate value of k to start with in the quadratic programming formulation.

Results of a Numerical Example

A numerical example problem for the least-cost poultry ration is given in Table 1, in which the cost of raw materials and their nutrient contents other than protein are known and constant. Seven possible raw materials for poultry feed are considered: yellow corn, alfalfa meal, corn distillers soluble, fish meal, meat and bone scraps, molasses, and soybean meal. Nutritive requirements and constraints considered are protein, fiber, calcium, phosphorous, energy, and weight [7]. The minimum protein requirement is specified as 23 percent of the weight of the final mixture.

For illustrative purposes, the required probability of success (β) in meeting the protein specification is not fixed at a certain level. Instead, the cost restriction (k) associated with quadratic programming is parametrized uniformly over the range of \$63.31 to \$65.11. \$63.31 is the least cost of a mixture which meets the protein requirement at best only 50 percent of the time.

Table 2 summarizes the results (obtained by using the Rand QP360 [4]) at every basis change of parametric quadratic programming for each different cost restriction level. The re-

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[6] Normal distribution of $p'x$ is assumed. Otherwise, Chebyshev's approximation must be applied.

Table 1. Linear programming model and standard deviation of protein contained in ingredient for least-cost poultry ration

Row Name and ID	Yellow corn x_1	Alfalfa meal x_2	Corn distiller solubles x_3	Fish meal x_4	Meat & bone scraps x_5	Molasses x_6	Soybean meal x_7	Constraint	Unit
Cost (C_j)	40.0	55.0	70.0	130.0	115.0	30.0	85.0	Min	$
Mean Protein ($\bar{P}_j$)	8.9	17.9	26.9	61.3	50.6	3.2	45.8	≥23.0	%
Fiber (A_{1j})	2.0	24.3	4.0	1.0	2.2	—	6.0	≤7.0	%
Calcium (A_{3j})	0.02	1.33	0.35	5.49	10.57	0.89	0.32	≥1.50	%
Phosphorous (A_{3j})	0.31	0.24	1.37	2.81	5.07	0.08	0.67	≥1.0	%
Energy (A_{4j})	3,430.0	1,653.0	2,932.0	2,866.0	1,984.0	1,962.0	2,249.0	≥3,200.0	Mcal
Weight (A_{5j})	1.0	1.0	1.0	1.0	1.0	1.0	1.0	=1.0	Ton
σ_j	0.55	0.63	0.60	1.28	1.21	0.20	0.72		

sulting E-σ boundaries are then summarized in Figure 4. The results show that when cost per ton is increasing, the associated E-σ boundary is moving to the right, resulting in a higher attainable q value along the boundary and thus a higher attainable probability of success. For example, when $k=\$63.61$, the highest attainable q value, denoted as $\bar{q}$, is equal to 0.4071, implying the protein requirement will be met 65.8 percent of the time; when $k=\$63.91$, $\bar{q}=0.8060$, implying the protein requiremen will be met 79.00 percent of the time; whe $k=\$65.11$, $\bar{q}=2.3619$ and thus the probabilit of success is 99.1 percent. Thus plans C_2, C_3 and C_7 in the table are the least-cost poultr rations which will meet the protein requirement respectively 65.8 percent, 79.0 percent and 99.1 percent of the time.

The resulting cost-probability of success relationship for the example problem is also sum

Table 2. Summary of results[a]

Cost per Ton	Plan	x_1	x_3	x_4	x_5	x_7	$\bar{p}'x$	$(x'Wx)^{\frac{1}{2}}$	$\frac{\bar{p}'x-23}{(x'Wx)^{1/2}}$	Probability of Success[b]
63.31	A_1	0.6450	0.1331	0.1782	0.0437		22.4566	0.4325	−1.2564	
	B_1	0.7053	0.0037	0.2019	0.0339	0.0552	22.9979	0.4696	−0.0045	
	C_1	0.7073		0.2023	0.0345	0.0559	23.0022	0.4709	0.0047	50.2[c]
63.61	A_2	0.6408	0.1350	0.1830	0.0412		22.6373	0.4337	−0.8362	
	B_2	0.7022	0.0033	0.2071	0.0312	0.0563	23.1887	0.4717	0.40	
	C_2	0.7040		0.2075	0.0317	0.0569	23.1925	0.4729	0.4071	65.8
63.91	A_3	0.6366	0.1370	0.1878	0.0386		22.8181	0.4351	−0.4181	
	B_3	0.6991	0.0028	0.2124	0.0285	0.0573	23.3795	0.4739	0.8007	
	C_3	0.7006		0.2127	0.0289	0.0578	23.3828	0.4749	0.8060	79.0
64.21	A_4	0.6323	0.1390	0.1926	0.0361		22.9988	0.4366	−0.0028	
	B_4	0.6960	0.0024	0.2176	0.0257	0.0583	23.5703	0.4763	1.1974	
	C_4	0.6973		0.2179	0.0261	0.0588	23.5731	0.4771	1.2012	88.5
64.51	A_5	0.6281	0.1409	0.1974	0.0335		23.1795	0.4382	0.4096	
	B_5	0.6929	0.0020	0.2228	0.0230	0.0594	23.7611	0.4787	1.5898	
	C_5	0.6939		0.2231	0.0233	0.0597	23.7634	0.4794	1.5924	94.4
64.81	A_6	0.6239	0.1429	0.2022	0.0310		23.3603	0.4399	0.8190	
	B_6	0.6898	0.0015	0.2281	0.0203	0.0604	23.9520	0.4813	1.9780	
	C_6	0.6906		0.2283	0.0205	0.0607	23.9537	0.4818	1.9793	97.6
65.11	A_7	0.6197	0.1449	0.2070	0.0284		23.5410	0.4417	1.2247	
	B_7	0.6867	0.0011	0.2333	0.0175	0.0614	24.1428	0.4840	2.3612	
	C_7	0.6872		0.2335	0.0177	0.0616	24.1440	0.4844	2.3619	99.1

[a] x_2 and x_6 are not activated in the solutions.

[b] Normal distribution of the protein content in each ingredient is assumed; probability of success is calculated only fo the highest attainable q value along each E-σ boundary.

[c] Because of the bounding error associated with the $63.31.

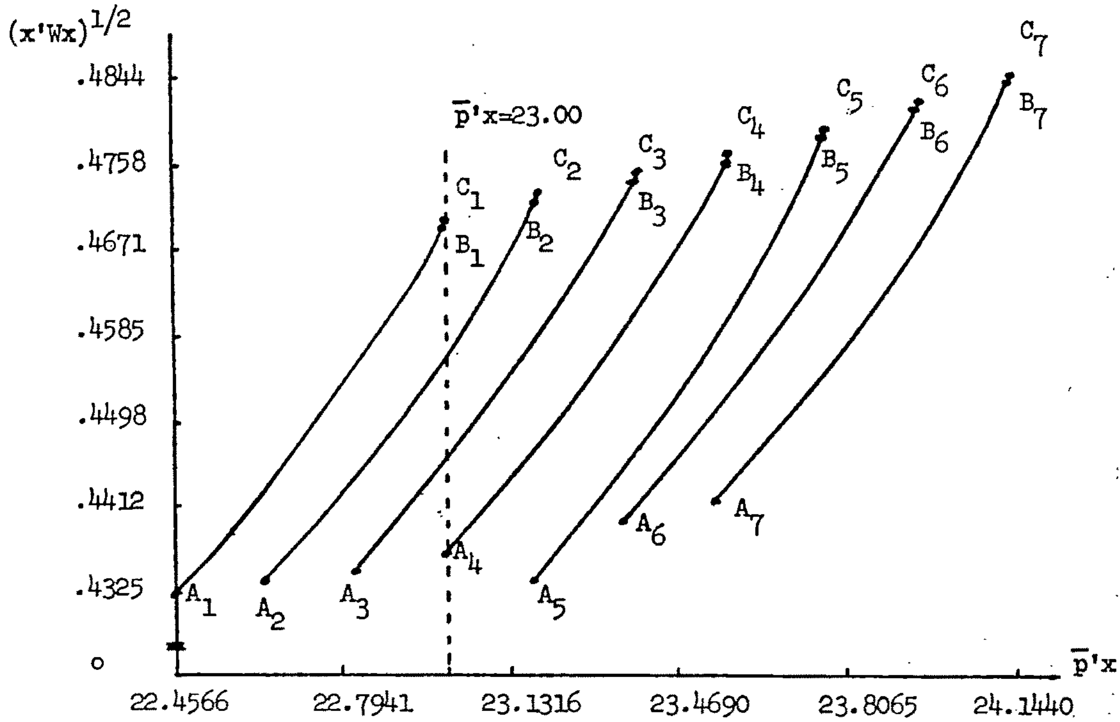

Figure 4. The E-σ boundaries for the example problem

marized in Figure 5 which shows that when cost is increasing, the probability of success is increasing at a decreasing rate and finally approaches one. The resulting cost-probability of success curve can also be used as a guide for approximating the specific k value for generating any desired result for the example problem.

For the example problem, the highest attainable q value, along each E-σ boundary, occurs at the last point of the quadratic programming results. This plan is equivalent to the linear programming result that maximizes mean protein ignoring risk. This is a possible case, but not a necessary one.[7] As stated before, the highest attainable q value, $\bar{q}$, may occur at any point along the E-σ boundary. That is, $\bar{q}$ may occur at any critical turning point of the QP solutions or at any point between any consecutive two of them. The diagrammatic analysis shown in Figure 1 can help allocate this point approximately. If $\bar{q}$ should occur between two consecutive turning points of QP solutions, then linear interpolation on these two points can be used because the Kuhn–Tucker necessary conditions for optimality at any turning point can be expressed as a linear function of $1/\alpha$, x, and ρ. The linearly interpolated solutions at intermediate $\bar{p}'x$ level should also satisfy the optimality conditions. ρ represents the dual variables associated with the linear constraints of QP. For this example, linear interpolations between points B_j and C_j have been carried out, and there is no better plan between them.[8]

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[7] In these particular data, the variances are small relative to the mean protein content in the ingredients. This also happens to be the case with Rahman and Bender's example problem [9]. One may argue that if this *is* the case, then the optimum plans could be more efficiently obtained by solving the standard parametric LP program:

Minimize

$$c'x$$

subject to

$$\bar{p}'x \geq d,$$

(for d over an appropriate range)

$$Ax \geq b,$$

and

$$x \geq 0.$$

However, this special characteristic is *not* necessarily typical of many other feeding problems. Without checking on the E-σ boundaries, one is not certain that this is the case for other problems.

[8] As a matter of fact, since C_j is better than B_j, only the points close to C_j (or the point right next to C_j, if you consider the points on the boundary as discrete) need be examined to prove that C_j is the best.

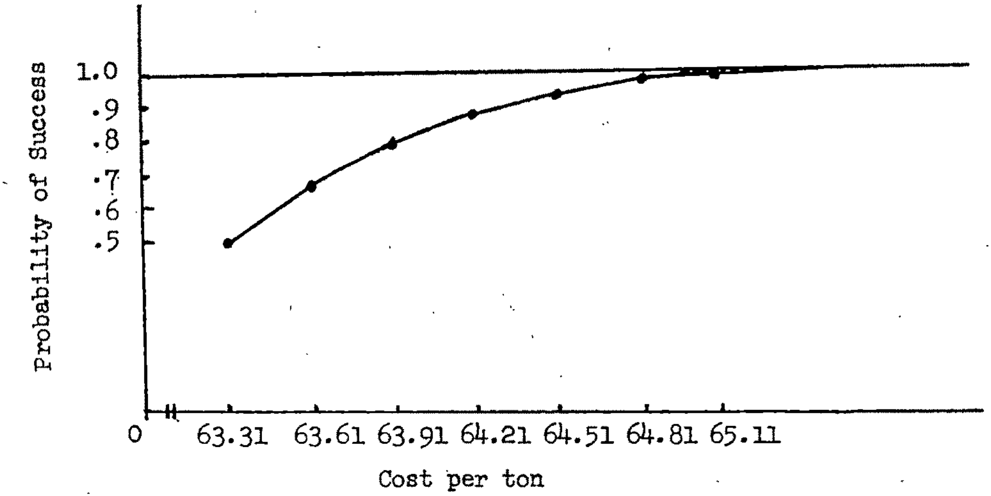

Figure 5. Cost-probability of success relationship for the example problem

Conclusion

It has been shown how a stochastic relationship can be incorporated in a quadratic programming model, solved iteratively for a least-cost feed mix, subject to a probabilistic protein constraint and other linear inequality restrictions. The quadratic programming codes currently available may not be very efficient for large problems. But the problem of least-cost poultry feed is usually well within the range of computational ease and feasibility.

The result obtained is optimal for the original stochastic programming problem specified as a chance-constrained programming model. Lack of true shadow price information is the only disadvantage. The dual results for the linear inequality restrictions from quadratic programming are not the true values for the original problem. The dual value for the probabilistic protein constraint is simply not available. Nevertheless, primal results concerning the optimal strategy are often the most important in any result.

This suggested procedure has obvious generality in other stochastic programming problems with linear objective function, numbers of linear restrictions, and one similar[9] probabilistic constraint. Cases associated with general farm planning or portfolio selection problems in which a linear objective function is optimized subject to a minimum probability restriction in meeting a target income are examples of problems other than the least-cost livestock feed formulation where the procedure can be applied. The appropriate value of k with which to start in the QP formulation may not be as evident. Practice can improve the judgment of an appropriate value to start with to accelerate convergence to the desired level of probability.

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[9] "Similar" means that the probability constraint must be so formulated to restrict the probability of meeting a certain *minimum* level of requirement no less than a certain percentage of time. Otherwise, for example with an upper bound restriction imposed for restricting the probabilistic fiber content of a feed mix, or a feasibility restriction imposed for restricting the probability resource requirement of a farm plan, the probability restriction is not similar to that of the above. If the probability of meeting a given *maximum* level of restriction is no less than a certain percentage of the time, the quadratic objective function to be maximized in the step II model formulation is not $[\bar{p}'x-\alpha(x'Wx)]$. Rather, it is $[-\bar{p}'x-\alpha(x'Wx)]$. Thus the entire procedure and its economic logic must be modified accordingly. Given the procedure stated in the text, one can easily derive this modified procedure.

References

[1] CHARNES, A., AND COOPER, W. W., "Chance Constrained Programming," *Mgt. Sci.* 6:73–79, 1959.

[2] ———, "Deterministic Equivalents for Optimizing and Satisfying Under Chance Constraints," *Oper. Res.* 11:18–39, 1963.

[3] CUNHA, T. J., *Swine Feeding and Nutrition*, New York, Interscience Publishers, Inc., 1957.

[4] CUTLER, L., AND PASS, D. S., *A Computer Program for Quadratic Mathematical Models to be Used for Aircraft Design and Other Applications Involving Linear Constraints*, R516-PR, Rand Corp., June 1971.

[5] KATAOKA, S., "A Stochastic Programming Model," *Econometrica* 31:181–196, Jan.-April, 1963.

[6] MARKOWITZ, H. M., *Portfolio Selection: Efficient*

Diversification of Investment, New York, John Wiley & Sons, Inc., 1959.

[7] National Academy of Sciences, *Nutrient Requirement of Poultry*, 6th Revised Edition, 1971.

[8] NOTT, H., AND COMBS, G. F., "Data Processing of Feed Ingredient Composition Data," *Feedstuffs* 39:21–24, Oct. 14, 1967.

[9] RAHMAN, S. A., AND BENDER, F. E., "Linear Programming Approximation of Least-Cost Feed Mixes with Probability Restrictions," *Am. J. Agr. Econ.* 53:612–618, Nov. 1971.

[10] VAN DE PANNE, C., AND POPP, W., "Minimum-Cost Cattle Feed under Probabilistic Protein Constraints," *Mgt. Sci.* 9:405–430, April 1963.

[11] Zoutendijk, G., "Maximizing a Function in a Convex Region," *J. Roy. Stat. Soc.* (B) 21:338–355, 1959.

[12] ———, *Methods of Feasible Directions: A Study in Linear and Non-Linear Programming*, Amsterdam, Elsevier Publishing Co., 1960.

Alternative Tax Treatment of Orchard Development Costs: Impacts on Producers, Middlemen, and Consumers*

HOY F. CARMAN AND JAMES G. YOUDE

Present federal income tax laws allow current deduction of development costs for most orchard crops. An economic surplus framework is used to analyze the impact of cost capitalization on producers, middlemen, and consumers. Estimated net social returns per dollar of tax subsidy range from $0.12 to $15.00 for five California orchard crops under present tax treatment.

PRIOR to 1970, development costs for all orchard crops could be treated as a current deduction in computing federal income taxes. Exploitation of this tax provision in the citrus and almond industries resulted in legislation that now requires capitalization of planting and development costs for these two crops.[1] However, development costs for other tree and vine crops continue to be deductible as annual operating expenses. Previous studies show that this tax treatment for orchard crops (other than citrus and almonds) yields a substantial tax incentive to farmers and nonfarm investors [2, 3].

Requiring capitalization of development costs for all orchard crops undoubtedly will be considered in future tax reform efforts. Such a change in public policy would have important implications for producers, middlemen, and consumers since the existing tax treatment of development costs results in larger production of orchard crops than would prevail if capitalization were required. Total revenue for producers of crops with inelastic demand is reduced; for crops with elastic demand total revenue is increased. Middlemen benefit from increased volume under the present tax treatment of development expenses, and it is expected that consumers benefit from increased volume at reduced prices.

In this paper costs and benefits accruing to producers, middlemen, and consumers of five California orchard crops that can now treat development costs as a current expense for tax purposes are estimated. The first section presents the analytical framework employed to evaluate costs and benefits for the various sectors. Next data sources are discussed. Then the estimated net social returns accruing to each sector from orchard development tax subsidies for the five commodities are presented. The concluding section summarizes overall findings and policy implications.

Analytical Framework

A partial equilibrium analysis is utilized to compare results of present orchard development tax treatment with estimated results if capitalization of development costs were required. The study focuses on the impacts of present orchard development incentives on producers, middlemen, and consumers of five California orchard crops: apples, apricots, avocados, freestone peaches, and olives.[2] The analytical framework, utilizing consumer and producer surplus, is based on previous work by Griliches [10], Peterson [13], and Schmitz and Seckler [16].

Supply response

Time lags between decisions to plant and resulting production, combined with tree removal and changing yields, complicate the estimation of supply functions for orchard crops. Considerable progress has been made in formulating models of supply response for perennial crops, but severe data problems exist.[3] In a recent

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[1] Davenport discusses the tax treatment of orchard development costs both before and after passage of the Tax Reform Act of 1969 [5, pp. 11–12 and 6, pp. 333–334]. The regulations concerning capitalization of development costs for citrus and almonds are contained in Section 278 of the Internal Revenue Code.

[2] These five crops represent a broad spectrum of demand, supply, and cultural conditions. The terms "incentives" and "subsidies" have specific meanings in this paper. Incentives are those tax provisions that stimulate orchard development. Subsidies refer to the economic impact of these tax provisions on each sector considered.

[3] For an example of model development and estimation, see the recent article in this *Journal* by French and Matthews [8].

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study, Hamilton calculated long-run tree-planting elasticities for a series of California tree crops using distributed lags.[4] He developed an adjustment procedure to derive consistent data series for the various acreage categories [11, pp. 270–318]. While there appear to be some problems in his formulation of economic models for certain crops, the estimated tree-planting elasticities for the five crops considered in this paper seem reasonable. As shown in Table 1, tree-planting elasticities for these five crops range from very inelastic to highly elastic.

Treating removals as a fixed percentage of bearing acreage and average yields as constant permits the use of tree-planting elasticities as an estimate of supply response.[5] That is, a given percentage change in planting is assumed to change production by the same percentage when the appropriate time lags are included. In a supply framework the tree-planting elasticities provide an estimate of the *shift* in supply as a result of changed cost conditions. The dynamic adjustment process in moving from one equilibrium position to the other is not considered here.

Table 1. Elasticity of tree planting and price elasticity of demand, five California orchard crops

Crop	Elasticity of Tree Planting[a]	Price Elasticity of Demand	
		Farm	Retail
Apples	.995	− .700[b]	−1.240[b]
Apricots	3.202	− .707[c]	−1.686[c]
Avocados	2.037	−1.130[d]	−1.440[e]
Freestone Peaches	1.494	− .898[f]	−1.140[g]
Olives	.236	−1.190[h]	−1.510[g]

Source: [a] [11, p. 264].
[b] [19].
[c] Farm and F.O.B. level estimates for canning and canned apricots [12, p. 57].
[d] Derived from retail elasticity of demand using elasticity of price transmission (n_j) = .788.
[e] [17].
[f] [12, p. 57].
[g] Derived from farm level elasticity of demand using n_j = .788.
[h] [15].

Elasticity of demand

The magnitude of price changes occurring as a result of a given shift in supply depends on the price elasticity of demand for a particular commodity. Consideration of impacts on consumers, middlemen, and producers requires farm-level and retail-level estimates of prices and price elasticity of demand for each crop. U. S. demand elasticities reported in other studies were used in all instances except for the farm-level demand for avocados and retail-level demand for freestone peaches and olives. These three elasticities (unavailable from other sources) were derived using an elasticity of price transmission equal to .788 and the relationship:[6]

$$E_{ij} = e_{ij} \cdot n_j$$

where:

E_{ij} = Elasticity of demand at farm level
e_{ij} = Elasticity of demand at retail level
n_j = Elasticity of price transmission.

In the studies utilized, the researchers estimated linear demand functions and calculated price elasticity of demand for an average price and quantity. These demand elasticities are presented in Table 1.

Consumer and producer surplus

Because acceptable supply elasticity estimates are not available, supply is treated as perfectly inelastic at each equilibrium position. For short-run and intermediate-run periods, an inelastic supply function is probably a good approximation for tree and vine crops. The addition of a derived demand curve (D_f) at the producer level permits division of what is traditionally termed "producer surplus" into two segments: middlemen and producer surplus (Fig. 1). More elastic supply curves would reduce the sum of middlemen and producer surplus but would not affect consumer surplus estimates.

To analyze the costs and benefits resulting from the present tax treatment of orchard development costs, it is necessary to shift supply from the present situation (S) to S', which includes capitalization of development costs (Fig. 1). Since the benefits of *present* orchard development tax provisions to the three sectors are

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[4] California is one of the few states with time series data on planting, removal, nonbearing, and bearing acreage for perennial crops. One must exercise care, however, when using the data because of reporting procedures used by individual counties.

[5] Treating removals as a fixed percentage of bearing acreage, while an approximation, is often the best estimate available. See for example [4, 7, 15].

[6] For a discussion of the concept of elasticity of price transmission and its derivation see [9, pp. 61–62]. The coefficient n_j = .788 is the average for the four fruit products reported by George and King [9, p. 62].

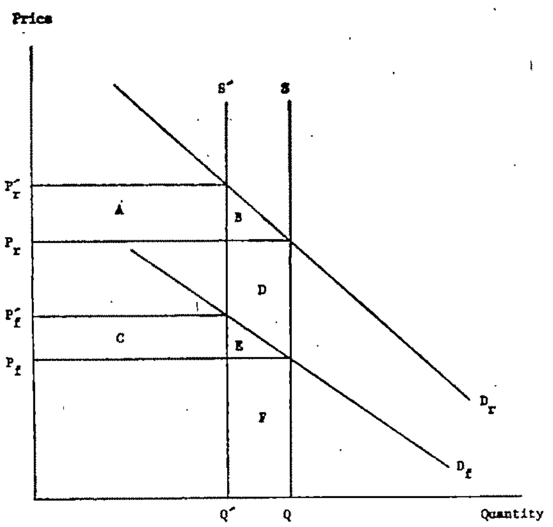

Figure 1

being analyzed, it is useful to assess the impacts of moving from S' to S in Figure 1:

(1) consumers surplus increases by areas $A+B$;
(2) middlemen surplus changes by areas $C+D+E-A$;
(3) producer surplus changes by areas $F-C$.

Gains to society, termed "gross social returns," are defined as

$$(A+B)+(C+D+E-A)+(F-C) = B+D+E+F.$$

To calculate "net social returns," the tax subsidy is subtracted from gross social returns.

The amount of tax incentive realized by an orchard developer depends on his tax bracket and the costs deducted from his current income. Suppose, for example, that the developer is in the 50 percent marginal income tax bracket; that capitalization would result in a capital account of $1,000 per acre; that the expected tree life of the orchard crop is 20 years; and that the relevant interest rate is 7 percent. Current deduction of the establishment costs of $1,000 would result in a tax saving of $500. If capitalization were required, the taxpayer could deduct only $50 per year for 20 years, with an annual tax saving of $25. The present value of a 20-year $25 annuity at 7 percent interest is $265. The difference in tax saving, defined here as the tax incentive, is $500–$265 = $235. For this analysis are capitalized all net costs of establishment, other than interest and taxes, until annual orchard income covers annual costs.[7]

Reed's studies of establishing California orchards were used to estimate the magnitude of costs which would be capitalized if legislation similar to that now in effect for citrus and almonds were extended to all orchard crops [14]. The development period ranged from four years for olives to eight years for apples and avocados. Apricots required six years and peaches five years.[8] Crop income, after payment of operating expenses, first was used to offset taxes and interest costs, with any remaining income used to reduce costs capitalized under revised tax treatment. Resulting capital accounts ranged from $399 per acre for olives to $2,951 per acre for avocados (Table 2).

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[7] Treasury regulations exempt taxes and interest from capitalization for citrus and almonds; we are assuming the same tax treatment in our analysis of these five crops.

[8] Capitalization of almond and citrus development costs is only required for four years after planting. If the grove takes longer than four years to become self-supporting, the developer will receive some tax benefit from deduction of costs.

Table 2. Average bearing life, period of cost capitalization, development costs capitalized annual depreciation, and current income tax incentive for development by marginal income tax bracket, five California orchard crops

Crop	Average Bearing Life	Number of Years Costs to be Capitalized	Capital Account[a] 1957–59 Dollars	Annual Depreciation	Tax Incentive by Marginal Income Tax Bracket			
					20 percent	30 percent	50 percent	70 percent
			---- dollars per acre ----					
Apples	40	8	1,879	46.98	251	376	626	877
Apricots	35	6	538	15.37	68	102	170	237
Avocados	30	8	2,951	98.37	346	519	865	1211
Freestone Peaches	20	5	621	31.05	58	88	146	204
Olives	50	4	399	7.98	58	87	145	203

[a] Source: [14].

Table 3. Bearing acreage, annual planting required to maintain acreage, and 1967–1971 average production, yields and prices, five California orchard crops

Crop	1971 Bearing[b] Acreage	Annual Planting Required to Maintain Acreage	Average Production[b]	Average[b] Yields	Average Prices[a]	
					Farm[b]	Retail[c]
	acres	acres	tons	tons/acre	dollars/ton	
Apples	22,640	566	240,800	10.94	59.80	246.80
Apricots	31,060	887	164,800	4.86	99.60	464.34
Avocados	18,380	613	54,120	2.91	311.20	864.44
Freestone Peaches	19,900	995	220,600	9.43	66.00	264.00
Olives	27,470	549	55,800	2.05	229.00	1,090.00

[a] 1967–1971 average prices, deflated (1957–59=100).
[b] 1967–1971 averages calculated from data in [1].
[c] Calculated from farm price by using estimated farmer's share of retail dollar for each crop.

Estimated tax incentives by the orchard developer's marginal income tax bracket are shown in Table 2. Calculations assume straight-line depreciation of the capital account over the bearing life of the orchard, with an interest rate of 7 percent used in calculating present values. Planting incentives are available for all five crops, with the amount of incentive varying directly with the size of the capital account and the income tax bracket of the developer. All prices and costs are deflated by the index of prices paid by farmers (1957–1959=100) to provide comparability.

Data on acreage, production, and yields are shown in Table 3. Planting required to maintain bearing acreage is based on 1971 bearing acreage and the assumed bearing life of the orchard. Retail prices were estimated from average farm prices and 1966–1971 data on farm to retail price spreads for fresh and processed fruit [18]. The estimated farmers' share of retail prices were; apples 24.23 percent; apricots, 21.45 percent; avocados, 36.00 percent; freestone peaches 25.00 percent; and olives, 21.00 percent.[9]

Social Returns

Consumer, middleman, and producer surplus were calculated for each of the five California orchard crops for developers having income placing them in the 20, 30, 50, and 70 percent marginal income tax brackets. With use of apples as an example, the calculations for a taxpayer in the 70 percent marginal tax bracket are as follows:

(1) Average 1967–1971 California apple production and prices are $Q=240{,}800$ tons, $P_f=\$59.80$ per ton, and $P_r=\$246.80$ (Table 3),

where

Q = average annual production of apples in California;
P_f = average farm-level apple prices in California; and
P_r = average retail apple prices in California.

(2) Calculated per acre tax incentives by tax bracket were converted to incentives per ton using estimated lifetime yields. The tax incentive is $877 per acre (Table 2), average yield is 10.94 tons per acre (Table 3), and bearing life is 40 years (Table 2). The incentive is thus $\$877 \div (10.94)(40) = \$2.00$ per ton. This is equivalent to a 3.34 percent decrease in returns per ton if capitalization were required.

(3) Using the elasticity of tree planting, the impact on production of removing the tax incentive was calculated. Using the definition of elasticity and the elasticity of apple tree planting (Table 1), the calculation is:

$$\text{percentage change in } Q = .995\ (3.34) = 3.323 \text{ percent.}$$

Applying this percentage to $Q=240{,}800$ tons, the change in Q is 8,002 tons and $Q'=232{,}798$ tons. This shift is shown by the movement from S to S' in Figure 1.

(4) The change in equilibrium quantities supplied, combined with elasticities of demand, provides estimates of price

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[9] The margin for avocados is from [17]. The other margins are a weighted average based on the proportions of the crop sold fresh and processed.

Table 4. **Estimated annual gross and net gains to consumers, middlemen, and producers of California apples, and tax subsidies for development by tax bracket of the developer**

Group	Tax Bracket of Developer			
	20 percent	30 percent	50 percent	70 percent
	- - - - thousand dollars - - - -			
Consumers	472	660	1,133	1,565
Middlemen	181	254	436	619
Producers	−59	−82	−136	−183
Gross Social Returns	594	832	1,433	2,001
Less Tax Subsidy	142	213	355	496
Net Social Returns	452	619	1,078	1,505

changes at the farm and retail levels.[10] The estimated change in farm level apple price is 4.75 percent or \$2.84 per ton, while at the retail level it is 2.68 percent or \$6.61 per ton. Thus, $P_f' = \$62.64$ and $P_r' = \$253.41$.

(5) Relevant areas shown in Figure 1 were calculated using the above prices and quantities and the following relations:

$$
\begin{aligned}
A &= (P_r' - P_r)Q' &&= \$1,538,795\\
B &= 1/2\,(P_r' - P_r)(Q - Q') &&= 26,447\\
C &= (P_f' - P_f)Q' &&= 661,146\\
D + E &= (P_r - P_f)(Q - Q') &&= 1,496,374\\
F &= P_f(Q - Q') &&= 478,520
\end{aligned}
$$

These areas are then used to calculate changes in consumer, middleman, and producer surplus when moving from S' to S.

Estimated gains and losses to consumers, middlemen, and producers of California apples as a result of current tax treatment rather than requiring development cost capitalization are shown in Table 4. Gross returns range from \$594,000 to \$2,001,000 depending upon the tax bracket of the developer. Deduction of tax revenue decreases leaves net social returns ranging from \$452,000 to \$1,505,000 for the tax brackets used in Table 4. Losses in producer surplus are more than offset by the tax subsidy. Society has realized a net return of approximately \$3.00 for every dollar of tax incentive going to California apple orchard developers when compared with estimated conditions if development cost capitalization were required.

California typically produces 6 to 8 percent of the U. S. apple crop, ranking fourth among all states in total apple production. Although the results presented in Table 4 are limited to California, it is assumed that changes in capitalization requirements would result from federal legislation and therefore would be national in scope.[11] Thus, calculated changes in net social returns would probably be increased by a factor of 10 to 15 for the entire United States. Extrapolation is limited to this wide range because of possible regional differences in supply response and apple orchard development costs.

Gross and net social gains and development tax subsidies are summarized for the five orchard crops in Table 5. The 30 percent marginal income tax bracket represents a typical situation for many California farmers. The 70 percent tax bracket is included to illustrate the incentives for high-income individuals to invest in orchards, and the resulting impacts on three sectors of society. The following four sections summarize the results for apricots, avocados, freestone peaches, and olives.

Apricots

Estimated increases in gross social benefits from California apricots as a result of treating development costs as a current expense range from \$983,000 to \$3,474,000, depending on the tax bracket of the developer. The relatively small tax subsidy to apricot producers results in net social returns only slightly less than gross returns. In fact the small development subsidy is not sufficient to offset losses in producer surplus, mainly because of the high tree-planting elasticity for apricots (Table 1). Therefore California apricot producers as a group incur a net loss of \$23,000 to \$48,000 as a result of current tax treatment of orchard development costs when compared with the capitalization alternative. A comparison of subsidies and returns indicates that society has realized a net return of about \$15.00 for each dollar of tax subsidy allowed to apricot orchard developers. California accounts for over 90 percent of total U. S. apricot production. Thus calculated gains

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[10] Price elasticities of demand are treated as constant for the very small calculated movements along the linear demand curves used in this study.

[11] Citrus and almond capitalization requirements resulted from federal legislation and are now embodied in U. S. Treasury regulations.

Table 5. **Estimated annual gross and net gains to consumers, middlemen, and producers, and tax subsidies for developers in 30 percent and 70 percent marginal income tax brackets, five California orchard crops**

Group	Apples	Apricots	Avocados	Freestone Peaches	Olives
30 Percent Tax Bracket			- - - - thousand dollars - - - -		
Consumers	660	863	1,239	533	36
Middlemen	254	737	508	96	15
Producers	−82	−123	98	−15	2
Gross Social Returns	832	1,477	1,845	614	53
Less Tax Subsidy	213	90	318	87	48
Net Social Returns	619	1,387	1,527	527	5
70 Percent Tax Bracket			- - - - thousand dollars - - - -		
Consumers	1,565	1,990	2,818	1,208	79
Middlemen	619	1,742	1,269	230	40
Producers	−183	−258	300	−31	4
Gross Social Returns	2,001	3,474	4,387	1,407	123
Less Tax Subsidy	496	210	742	203	111
Net Social Returns	1,505	3,264	3,645	1,204	12

would increase only slightly for the entire United States.

Avocados

Elastic demand for avocados at the farm level results in a pattern of returns different than for apples or apricots. All three groups have increased their surplus as a result of producers currently deducting development costs rather than capitalizing them. Growers benefit two ways: they realize producer surplus, and they also receive a tax subsidy. Producer benefits range from $272,000 to $1,042,000 depending upon their average tax bracket. The large magnitude of the tax incentive (compared to the other four crops) is the result of relatively high development costs (Table 2). Society has realized a net return of approximately $4.80 for every dollar of tax subsidy to avocado orchard developers.

The production of avocados is limited to areas with relatively mild winters; approximately 80 percent of U. S. production is located in California and most of the remainder is located in Florida. While development costs and supply response may differ slightly between California and Florida, increasing the estimates in Table 5 by 25 percent probably would provide a fair representation of the impact of orchard development tax subsidies on the entire U. S. avocado industry. A limited amount of land is climatically suitable for avocado production, and competition for this land for urban developments probably has been a major impediment to increased avocado orchard development, even though producer surplus is expected to increase as production expands.

Freestone peaches

The pattern of gains and losses for freestone peaches from present development tax policies is similar to apples and apricots. Producers lose surplus because of an inelastic farm-level demand for peaches. However, this decrease in producer surplus is more than offset by orchard development tax subsidies, resulting in a net producer subsidy of $47,000 to $172,000 for California freestone peach producers. The proportion of social gains accruing to consumers (86 percent) is larger than for any other crops analyzed. Society has realized net gains of about $6.00 per dollar of tax subsidy granted developers.

Freestone peaches are grown in all regions of the U. S., but California is the largest producing state. In recent years California has produced from one-fourth to one-third of the nation's freestone peach crop. Yields normally are higher in that state than in other areas. While complete data on freestone peach acreages do not exist, it is estimated that between 14 and 17 percent of total U. S. freestone peach acreage is located in California. However, estimates of tree-planting response coefficients and orchard development costs in other regions would be necessary before the California values could be extrapolated as U. S. estimates.

Olives

Increases in gross and net social benefits from treating olive orchard development costs as a current expense rather than as a capitalized cost were lower than for any other crops considered. The major factor leading to this result is the very low elasticity of tree-planting for olives

(Table 1). Apparently olive orchard plantings are relatively unresponsive to changes in development costs. The pattern of gains for olives is similar to avocados, since olive demand is elastic at both the farm and retail levels. Consumers realize about two-thirds of the estimated increases in gross social benefits. Tax subsidies are almost as large as gross social returns for each tax bracket. The result is a low net social return as a consequence of the tax subsidy—about $0.12 for each dollar of subsidy. California is the only important olive-producing state in the U. S.; hence, the estimates in Table 5 can be regarded as representative of the entire U. S. industry.

Conclusions and Policy Implications

To determine gains and losses accruing to producers, middlemen, and consumers as a result of orchard development tax incentive policies, the responsiveness of orchard tree plantings to changes in costs is combined with farm and retail demand elasticities for orchard crops. One method of assessing the relative impact of these incentives on various sectors of society is to compare the net social returns resulting from the subsidy with expected results under an alternative tax policy. For the five orchard crops analyzed here, combined net returns to consumers, middlemen, and producers as a result of present orchard development tax regulations (rather than cost capitalization) ranged from $0.12 per dollar of subsidy for olives to $15.00 per dollar of subsidy for apricots. While the distribution of gains varied by commodity, consumer surplus was the largest segment of gross social returns for all crops and income tax brackets considered. Middlemen surplus as a result of treating development costs as current operating expenses was positive for all cases analyzed.

Since this analysis includes only five orchard crops, categorical statements cannot be made about the scope and incidence of benefits from present orchard development tax policies. However, the diverse nature of the crops considered here leads to the intuitive conclusion that the *direction* (if not the magnitude) of impacts would be similar if all orchard crops with similar tax treatment of development costs were considered. It is believed that the application of consumer-middleman-producer surplus analysis to all these commodities would show that consumers and middlemen have derived the largest gains from tax subsidies for orchard development. It also appears that—while the concern of existing commercial producers over the impact of these tax subsidies on their future returns is justified—benefits to growers as a group (including new entrants taking advantage of the tax subsidies) are positive for most commodities.

The *efficiency* of present orchard development tax incentives in allocating resources or distributing income among producers, middlemen, and consumers has not been considered. While these topics are germane to a consideration of alternative tax policies, they are beyond the scope of this paper.

Tax reform will become an increasingly important public policy issue during the next decade. Taxation of capital gains and enterprise development costs has already been identified by policy-makers as a high-priority issue in possible tax-reform legislation. If the extension of capitalization requirements to perennial agricultural crops (in addition to almonds and citrus) becomes an important policy consideration, it is hoped that the dialogue will consider the impacts of proposed tax-law changes on *all* sectors of the food system—including producers, marketers, and consumers.

References

[1] California Crop and Livestock Reporting Service, *California Fruit and Nut Statistics*, Sacramento, annual issues 1967–1971.

[2] CARMAN, HOY F., "Tax Loss Agricultural Investments After Tax Reform," *Am. J. Agr. Econ.* 54:627–634, Nov. 1972.

[3] ———, AND DAVID E. KENYON, "Tax Shelter Aspects of Orchard Development Before and After Tax Reform," *HORTSCIENCE* 7:105–107, April 1972.

[4] ———, *Economic Aspects of Producing and Marketing California Apples*, Giannini Foundation Res. Rep. 201, University of California, April 1969.

[5] DAVENPORT, CHARLES, "A Bountiful Tax Harvest," *Texas Law Rev.* 10:1–53, Dec. 1969.

[6] ———, "Farm Losses Under the Tax Reform Act of 1969: Keepin' 'em Happy Down on the Farm," *Boston College Industrial and Commercial Law Rev.* 12:319–350, Feb. 1971.

[7] FRENCH, BEN C., AND RAYMOND G. BRESSLER, "The Lemon Cycle," *J. Farm Econ.* 44:1021–1036, Nov. 1962.

[8] FRENCH, BEN C., AND JIM L. MATTHEWS, "A Supply Response Model for Perennial Crops," *Am. J. Agr. Econ.* 53:478–490, Aug. 1971.

[9] George, P. S., and G. A. King, *Consumer Demand for Food Commodities in the United States with Projections for 1980*, Agr. Exp. Sta., Giannini Foundation Monograph 26, University of California–Berkeley, March 1971.

[10] Griliches, Zvi, "Research Costs and Social Returns: Hybrid Corn and Related Innovations," *J. Pol. Econ.* 66:419–431, Oct. 1958.

[11] Hamilton, Joel R., "Acreage Response: An Econometric Analysis of the Acreage of Selected California Fruit and Nut Crops," unpublished Ph.D. thesis, University of California, 1971.

[12] Kip, Ergun, and Gordon A. King, *The Demand for Selected Deciduous Tree Fruits with Implications for Alternative 1980 Production Levels*, Agr. Exp. Sta., Giannini Foundation Res. Rep. 309, University of California, June 1970.

[13] Peterson, Willis, "Return to Poultry Research in the United States," *J. Farm. Econ.* 49:656–669, [illegible] 1967.

[14] Reed, A. D., *An Analysis of Orchard Development Costs*, revised ed., Agr. Exp. Sta. AXT-174, University of California, Aug. 1970.

[15] Roark, Don, *The California Olive Industry: Economic Environment, 1969*, Giannini Foundation Res. Rep. 304, University of California, Aug. 1969.

[16] Schmitz, Andrew, and David Seckler, "Mechanized Agriculture and Social Welfare," *Am. J. Agr. Econ.* 52:569–577, Nov. 1970.

[17] Sosnick, Stephen H., "Orderly Marketing for California Avocados," *Hilgardia* 33:707–772, Dec. 1962.

[18] U. S. Department of Agriculture, *Marketing and Transportation Situation*, ERS MTS-168, MTS-176, MTS-184, Feb. 1968, 1970, 1972.

[19] Waugh, Frederick V., *Demand and Price Analysis, Some Examples from Agriculture*, USDA ERS Tech. Bull. 1316, Nov. 1964.

Short Articles and Notes

An Approach to Farm Management Education*

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As farm management education programs evolve to serve business–oriented farm firms, planning, implementation, and control functions become major areas of emphasis. Integration of three computerized management tools—a budget generator, a management game, and LP-FARM—in a farm management course provided students with practical experience in each management function.

COURSE structure and computer assisted techniques are being used at Oklahoma State University to emphasize the processes of planning, implementation, and control in a senior level farm management course. A key component of this course is the direct utilization of computerized tools by students to solve farm management problems. It is recognized that teaching a student how to use service-oriented computer programs does not necessarily teach the concepts that can be used in further analyses. However, these programs can be used to reinforce theoretical and analytical concepts and provide experience in performing managerial functions.

The general objectives of undergraduate farm management courses can be summarized as teaching the student to integrate concepts and information from the biological, physical, and social sciences in making decisions and to apply decision-making procedures to the problems of organizing and operating the farm business. As educational programs in farm management evolve to serve larger–scale business–oriented farm firms, the processes of planning, implementation, and control become the major areas of emphasis [8, 9]. Continued emphasis on the planning process is a necessary, but not a sufficient condition for successful completion of the objectives of farm management education. Experience in the *implementation* of plans and *control* of the farm business should be provided to bolster student interest in learning to use the planning process effectively and to prepare them for successful farm management careers. While the general objectives of farm management education may remain the same, increased emphasis on the processes of implementation and control will enhance the degree to which these objectives are achieved.

The course organization and ideas to be presented have evolved from discussions with colleagues and trial and error selection over several years. Formal experiments have not been conducted to test for significant differences in achieving course objectives. However, the authors have found certain tools and techniques useful in enhancing farm management education and present them not as complete answers, but as ideas to stimulate professional dialogue on alternative approaches to undergraduate farm management education.

Planning and Implementation

The farm management game

A farm management game is introduced early in the course, usually during the second hour of class time.[1] A wide range of realistic crop and livestock activities are included in the game, and government program choices reflect current legislation [5]. Students must make crop and livestock choices, pay family living and overhead expenses, and conform with financial obligations such as debt constraints and loan payments on land, machinery, and cows. Livestock prices and crop and pasture yields have stochastic, trend, and cyclic components which are developed within the computerized game.

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[1] A laboratory farm was dropped in favor of a game farm several years ago as a basis for whole–farm planning problems. In controlled experiments, Curtis has found that business games can be an effective teaching tool for management education; see [4].

The major role of the game is to provide managerial experience in applying concepts and using data developed in the course. The game farm serves as a reference point for introducing discussion of farm planning and management problems and concepts. It is used to illustrate application of analytical techniques and as a means of implementing decisions after analyses have been completed. For example, students use enterprise budgets and partial budgeting in making decisions on the game farm and implement the decisions in a subsequent year of the farm's operation. Thus, gaming exploits both cognitive and associative learning principles. That is, the student learns to solve different problems by choice and application of appropriate problem solving techniques, and he also learns to respond to problematic situations in a rational and reasonable manner [10, 11].

Classroom experiences at Oklahoma State University over a five–year period suggest that the use of gaming as a central focus for the course has the following benefits:

(1) Gaming motivates the students to learn techniques such as partial budgeting and linear programming because they have an immediate need for them. It also encourages students to use these concepts throughout the semester rather than only on the exercise(s) assigned.

(3) The game farm is an invaluable source of class examples to clinch teaching objectives. The student need not wonder forever what expected values and variances have to do with enterprise budgets and choosing crop and livestock enterprises.

(3) Diversification, flexibility, liquidity, insurance, reserves, and "sure" enterprises do not remain abstract words to the students. They can identify use of these strategies and their effects on operation of the game farm.

(4) Planning, implementation, and control can all receive meaningful emphasis. For example, the relationship between a planning tool, such as a partial budget, and a control tool, such as a profit and loss statement, becomes clear as the student "operates" the farm through time. Additionally, the effects of financial constraints and variable receipts on ability of the farm to survive and grow are illustrated.

(5) Students receive the equivalent of elementary farm management experience. Evidence of management experience is reflected by student discussion in and out of the classroom, by performance on examinations designed to test the student's ability to apply concepts and techniques, and in students' reactions to new situations in the game operation. Because the game includes uncontrollable events, the student is not graded on game results.

Experience also indicates these benefits can easily be lost if:

(1) The game emphasizes computations more than management. Repetitive computations should be computerized.

(2) The game is *not* developed progressively. Additional enterprises, development of irrigation, land rental, and land purchase are successively introduced into the game after a few years of game farm operation to maintain interest and introduce new considerations.

(3) The game is unrealistic. Students accept abstractions such as indefinite farm locations, but resist outdated farm programs, prices, and production practices.

The budget generator

The Budget Generator is a systematic computerized procedure used to develop enterprise and cash flow budgets for a specified set of assumptions [6, 7, 12, 13, 14]. Data on physical production relationships and prices are developed externally for input to the system. This information is combined with internally calculated fixed and variable cost estimates for machinery and equipment to generate enterprise and cash flow budgets with a standardized, readable format. In addition to easing computational burdens, the Budget Generator facilitates standardization in the calculation of cost and return items for different enterprises as well as in the presentation of results to the user.

The Budget Generator has made significant contributions to classroom instruction in the senior farm management class. Availability of the system has convinced students that it is feasible to develop a comprehensive set of activity budgets as a step in farm planning. They are not overwhelmed with the clerical tasks. The theoretical concepts, computational procedures, format, and data sources are discussed, and students prepare several budgets for the game farm to develop understanding and skills.

Then the instructor leads the class to project needs and specifications for additional game farm enterprise budgets which are prepared using the Budget Generator and given to the students.[2] Thus use of the Budget Generator enables the student to spend more time on concepts relating to preparation and use of enterprise budgets while obtaining an adequate understanding of the mechanics of budgeting.

The section of the course on machinery costs relies on the Budget Generator for examples and illustrations. By setting machine cost, hours of machine use, interest rates, salvage values, and other parameters at alternative values in separate Budget Generator runs, numerous economic relationships are easily illustrated. Other important analytical phenomena easily illustrated by output from the Budget Generator include enterprise cash flow, rental–ownership comparisons for land or equipment, economic feasibility, and effects of yield and price changes on enterprise net returns.

Farmers in Oklahoma can secure the services of the Budget Generator through County Extension Directors. Extension personnel from county to state level are involved in preparing base budgets for use in extension education programs and research. This process contributes to keeping budgets current. Thus the Budget Generator helps bring more current and accurate information and sharper illustrations into the classroom. As a result, students' confidence in the course and the instructor is increased. The overall program encourages students to learn the format and use of the budgets because they can reasonably expect an opportunity to use the program and results in the future. These attributes of relevance are important to students.

The enterprise budgets are used as a basis for whole–farm partial budgeting procedures. After these procedures have been taught, applied to planning problems in the game farm, and advantages and shortcomings noted, attention is diverted to planning using linear programming.

LP-FARM

The LP-FARM program consists of three main components—a data generator, a solution algorithm, and a report writer [1, 2, 3]. The data generator takes information from an input form specially designed for a user with limited linear programming background and converts it into the matrix form required by the solution algorithm. The solution algorithm for LP-FARM is the standard simplex procedure. The report writer converts the optimal solution information into a set of production, marketing, and financial reports that can be readily understood by the user.

Linear programming is presented as an alternative to hand budgeting in the course. A graphic illustration of the concepts of the linear model and a discussion of the data requirements and assumptions are first presented. Then a detailed exercise on constructing a simplified LP tableau for the game farm (approximately a 15 by 15 matrix) and a summary of the information obtained from linear programming are discussed. Finally, LP-FARM is introduced to make linear programming operational for the student. Students set up the input forms required for LP-FARM and then learn to read and interpret the output. Students are also required to use LP-FARM to analyze either an actual farm or ranch of their choice or a realistic alternative for which the appropriate data are available.

One significant advantage of using LP-FARM in the classroom is that it operationalizes the discussion of whole–farm planning without making great demands on the student in terms of a background in linear programming. The budgeting approach suffers from the tedious and time–consuming calculations required to generate one, let alone a number of partial budgets. Because of the flexibility of LP-FARM, not only can the importance of whole–farm analysis and the interaction between enterprises in resource use be discussed and illustrated with a specific example, these can be reinforced through analysis by the students of their own farm situations. This practical application to a problem that is real for each student helps convince them that whole–farm analysis can be used to *solve* as well as *conceptualize* farm management problems.

The section of the course on whole–farm planning includes discussion of key concepts that are illustrated by formulating, solving, and analyzing an LP-FARM problem. For example, competitive, complementary, and supplementary enterprise relationships are illustrated with linear programming rather than a two dimensional blackboard graph or other traditional teaching aids. Students are quick to grasp the implications of shadow prices and ranges of linearity and can relate them to a concurrent review of marginal principles. The concept of opportunity cost and the impact of noneconomic decisions are also vividly illustrated by loss in net revenue associated with various types of personal preferences that the user may include in the model.

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[2] Those students requesting to learn the mechanics of completing the input forms are given this instruction outside of scheduled class time.

In addition to reinforcing theoretical concepts, LP-FARM is a convincing means of illustrating the important role that resource endowments and availability play in farm management. Shadow prices indicate to the student those resources currently available in excess quantities as well as the relative availability and productivity of other resources. Furthermore, a comparison of LP-FARM solutions illustrates the effect of relative resource endowments on the optimum combination of enterprises. Thus students understand the simple concept that farms with the same acreage may have quite different profit maximizing organizations if different quantities of capital or family labor are available.

Control[3]

The essential components of a control system, *ex ante* farm budgets and *ex post* farm records, are already operational tools in the farm manager's tool kit. However, it is questionable if farm management courses on the campus have adequately explained how these tools can be coordinated to determine why actual performance deviates from budgeted expectations or how decisions could be improved. While it is easy to list and discuss the usefulness of records for computing taxes, dividing returns under partnership, corporation and labor incentive agreements, and comparative analysis, it is difficult to convince students that records represent more than a summary of the past. However, emphasis on records for control purposes may convince students of the usefulness of farm record systems in forward planning.

Use of the farm management game as a central focus for the course provides a means to emphasize the control function and usefulness of record data. Students playing the management game prepare a budgeted income and expense statement, implement the plan through the game, and then compare the "actual outcome" with the budgeted plan. Comparisons between student teams in and out of class provide an evaluation of different courses of action in one year and over time. The game output lists, yield levels, product prices, cash income and expense by item, and a net worth statement. Students feed information from the comparison of actual outcome to budgeted expectations into the planning process for the coming year and thus learn the elements of control. Students can also use the game output to develop enterprise accounts and data for a comparative analysis among student–farmers and between years on one farm.

Possibilities to add realism to undergraduate farm management education programs by emphasizing the control function appear unlimited. Experience with the course suggests that using computer tools permits sufficient emphasis on the planning and implementation functions such that a misallocation of the most limiting resource (instructional hours) may result unless greater emphasis is devoted to the control function.

General Benefits of Computerized Management Tools

A major contribution of using the computerized tools is that they provide the means to coordinate and integrate extension and on-campus educational programs. It is emphasized in the classroom that the Budget Generator and LP-FARM were developed as extension tools to help farmers analyze and solve actual problems. Extension personnel frequently assist in presenting materials in class and have spent a substantial amount of time answering student questions on LP-FARM outside of class. After having been exposed to LP-FARM in the classroom, those students who return to the farm or work with farmers in some capacity are aware of its usefulness and can work directly with the area extension specialists to apply the procedure to their problems. Many students have discussed the program and the results with their families, resulting in some changes in farm organization and inquiries as to the availability of the program. Because of the personal exposure to extension personnel, students are more likely to contact them when they need assistance in solving specific problems after they have left campus.

Use of computerized management tools gives a rapid application turnaround. The importance of accurate data can be quickly illustrated and suggestions can be made concerning which physical coefficients are the most important and must consequently be the most accurate. The importance of accurate data is most effectively substantiated by "nonsense" results from the students' Budget Generator and LP-FARM applications which can be traced to inaccurate data or incorrect problem specification.

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[3] For discussions of control as a basic process of management which go beyond the scope and space limitations of this paper, see [8, pp. 637–642; 9, pp. 407–418].

Finally, use of these management tools allows the instructor to concentrate his discussion on management issues rather than tedious calculations or abstract mathematics. In particular, the LP-FARM procedure does not require the student to know matrix algebra or matrix manipulation. He also is not asked to complete tedious calculations as required in hand budgeting or even programmed planning. Thus the class can confront *more* management issues and yet obtain sufficient expertise in the utilization of analysis techniques to analyze these issues accurately.

Problems of Computerized Management Tools

Certain problems can arise in using computerized planning tools unless appropriate plans are made. First, it is important that the tools be used to teach a concept or an analytical procedure. One must be careful that the mechanics of filling out the proper forms do not overshadow the concepts being taught.

The use of computerized planning tools in on-campus educational programs will undoubtedly increase the cost per credit hour taught. The computer cost of using the farm management game, LP-FARM, and the Budget Generator in the classroom is about $400 a semester for a class of 40 to 50 students.[4] This cost estimate does not include debugging costs or services such as keypunching and verifying. In addition substantial professional time is required to counsel with students analyzing their own farm operations. Not including the classroom time spent in explaining the LP-FARM input and output forms, approximately three to four hours of professional time is required per student to assist him in analyzing his farm. For those students who do not program their own farms but utilize the resource, budget, and farm information available, only about one hour of professional time is required per student.

An additional problem that can arise in using these tools is one of classroom and course planning. Substantial prior planning must occur to ensure that the computer results to be discussed have been run and checked for errors. Debugging of any program problems should be accomplished well before the semester begins, and the instructor must utilize the program including filling out the appropriate forms so that he is aware of interpretation problems and other issues which might raise student questions.

A final problem concerns evaluation of student performance in a course stressing use of computerized management tools and gaming as learning devices. The game involves management practice in an uncertain environment. The desired result is that the student demonstrate appropriate use and understanding of planning concepts and techniques. The student is frequently asked to defend his gaming decisions but not the outcome, although he must live with the outcome in subsequent plays of the game. In addition the student has an opportunity to demonstrate understanding of concepts through laboratory exercises, examinations, and a term problem involving use of LP-FARM. The latter provide the basis for the student's course grade.

Conclusion

Increased emphasis on business management concepts in farm management education programs is long overdue. Consistent with this emphasis is the utilization of computerized forward planning techniques. The additional step of coordinating use of planning techniques with *ex post* records for control purposes should be further emphasized in such courses. A benefit–cost ratio for using these tools in education programs has not been systematically estimated. Judgment and experience suggest that the ratio is certainly greater than one. However, it must be reemphasized that teaching students to use these tools may not accomplish educational objectives unless the tools are used as a means of teaching *concepts*.

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[4] The "in house" computer processing rates at Oklahoma State University are approximately $320 per hour of CPU time.

References

[1] BITNEY, LARRY L., "An Application of Linear Programming to Individual Farm Management Decisions Using an Area Information System," unpublished Ph.D. thesis, Oklahoma State University, 1969.

[2] BRANT, WILLIAM L., AND TED R. NELSON, *User's Guide to LP-FARM*, Dept. of Agr. Econ. A.E. 7205, Oklahoma State University, July 1972.

[3] CANDLER, W., M. D. BOEHLJE, AND R. SAATHOFF,

"Computer Software for Farm Management Extension," *Am. J. Agr. Econ.* 52:71–80, Feb. 1970.

[4] CURTIS, SAMUEL E., "The Use of a Business Game for Teaching Farm Business Analysis to High School and Adult Students," *Am. J. Agr. Econ.* 50:1025–1033, Nov. 1968.

[5] EIDMAN, VERNON, *et al.*, "A Game for Management Instruction: The Oklahoma Panhandle Farm Version," Oklahoma Agr. Exp. Sta. research report in process, Oklahoma State University, 1973.

[6] KLETKE, DARREL D., "The Oklahoma State University Budget Generator: Farm Cash Flow Analysis," Oklahoma Agr. Exp. Sta. research report in process, Oklahoma State University, 1972.

[7] ———, *User's Manual: Oklahoma State University Livestock Budget Generator*, Oklahoma Agr. Exp. Sta. Res. Rep. P-661, Oklahoma State University, April 1972.

[8] KOONTZ, HAROLD, AND CYRIL O'DONNELL, *Principles of Management*, 4th ed., New York, McGraw-Hill, 1968.

[9] NEWMAN, WILLIAM S., *Administrative Action: The Techniques of Organization and Management*, Englewood Cliffs, N.J., Prentice-Hall, Inc., 1961.

[10] SCHNEEBERGER, KENNETH C., "Gaming as an Instrument of Farm Management Education—A Development and Evaluation," unpublished Ph.D. thesis, Oklahoma State University, 1968.

[11] WALKER, ODELL L., AND WAYMON A. HALBROOK, "Operational Gaming and Simulation as Research and Educational Tools in the Great Plains," *Economics of Firm Growth*, Great Plains Agr. Council Publication No. 29, June 1969, pp. 37–54.

[12] WALKER, RODNEY L., "On an Automated System for Developing Enterprise Budgets: the ERS Experience," contributed paper at the Annual Meeting of the American Agricultural Economics Association, Gainesville, Fla., Aug. 1972.

[13] WALKER, RODNEY L., AND DARREL D. KLETKE, *The Application and Use of the Oklahoma State University Crop and Livestock Budget Generator*, Oklahoma Agr. Exp. Sta. Res. Rep. P-663, Oklahoma State University, July 1972.

[14] ———, *User's Manual: Oklahoma State University Crop Budget Generator*, Oklahoma Agr. Exp. Sta. Progress Rep. P-655, Oklahoma State University, Nov. 1971.

On the Timing and Application of Pesticides*

Darwin C. Hall and Richard B. Norgaard

The model developed by J. C. Headley to illustrate the entomologists' concept of the economic threshold is presented and criticized. A two-variable model directed at the problems of optimal timing and pesticide application as well as optimal pest population level is presented.

For economic, ecological, and social reasons, preventative spraying with heavy doses of nonselective, persistent insecticides is becoming obsolete. Pest resistance, rapid pest resurgence due to a lack of natural control by predators recently killed from application of pesticides, socially unacceptable environmental costs, and other phenomena resulting from preventative spraying have gradually led to more remedial spraying with selective pesticides. Entomologists are now promoting integrated control, i.e., using the best combination of all known inputs and techniques including biological controls, cultural practices, and chemical approaches. The philosophy of integrated control is well established; but, due to the disaggregated approach of past entomological research and the limited attention paid by economists to the problem, methods are still ad hoc. The dichotomy between the state of the philosophy and that of the practice is illustrated by considerable concern over the "economic threshold," a term used by entomologists to denote the pest population level at which controls should be initiated [3, p. 240]. Entomologists advocate using all inputs in their best combination and simultaneously admit considerable uncertainty as to when and how even a single control input, such as an insecticide, should be used.

The Headley Model

The definition of the economic threshold has recently been investigated by J. C. Headley within the framework of a simple pest population growth model and a single application of a pesticide [2]. The model relates crop damage in dollars to pest density and time. The economic threshold is that population level where the marginal benefit from damage prevented by the control program is equal to the marginal cost of realizing that population through a control program. The model has four basic elements: a pest population growth function (equation 1.1), a pest damage function (equation 1.2), a product yield function (equation 1.3), and a pest control cost function (equation 1.4). Each of these elements is presented below.

$$P_t = P_{t-n}(1+r)^n \tag{1.1}$$

$$D_t = bP_t^2 - A \tag{1.2}$$

$$Y = N - cD_t \tag{1.3}$$

$$K = \frac{h}{P_{t-n}} \tag{1.4}$$

where

P_t = pest population level at time period t, the harvest time;

P_{t-n} = pest population level n periods prior to t;

r = net growth rate of the pest population per time period;

D_t = cumulative damage at time period t, given as a function of P_t, where the pest population has grown from P_{t-n} to P_t with no external interruption;

A = a constant related to the pest damage tolerance level based on the recuperating potential of the crop;

b = a parameter relating units of pest population to units of crop damage;

Y = realized product yield at harvest time (t) in dollars;

N = potential yield at harvest time if no pest damage, expressed in dollars;

c = a parameter relating damage units to dollars;

K = total cost in dollars of reducing the pest population to P_{t-n} at time $t-n$;

and

h = a parameter relating the inverse of population units to dollar units of control costs.

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Combining the first three equations yields:

$$(1.5)\qquad Y = N - c\{b[P_{t-n}(1+r)^n]^2 - A\}.$$

The marginal change in yield due to an incremental increase in the pest population level at time period $t-n$ is:

$$(1.6)\qquad \frac{dY}{dP_{t-n}} = -\,2cb(1+r)^{2n}P_{t-n}.$$

The marginal change in the cost of pest control due to an incremental change in pest population at time period $t-n$ is:

$$(1.7)\qquad \frac{dK}{dP_{t-n}} = -\,\frac{h}{P_{t-n}^2}\,.$$

Equating marginal revenue to marginal cost determines the optimal level to which the population should be reduced during time period $t-n$:

$$(1.8)\qquad P_{t-n} = \left(\frac{h}{2cb(1+r)^{2n}}\right)^{1/3}.$$

This is Headley's economic threshold. It indicates the level to which the pest population should be reduced during time period $t-n$ such that the damage due to the growing pest population between $t-n$ and harvest time t is minimized subject to the cost of pest control.

Headley's model nicely illustrates several of the factors which must be considered in any definition of the economic threshold. Nevertheless, it has several limiting assumptions. First, Headley implicitly assumes that the period of pesticide application $t-n$ is "entomologically determined."[1] Thus pest damage prior to $t-n$ cannot be controlled and is not considered in his model. Figure 1 illustrates the relationships between pest population and time in the model. The economic threshold, as defined by Headley, is the level P_{t-n} to which the population should be reduced rather than the population level $P_{t-n-\Delta}$ at which controls would be initiated. Previous definitions of the economic threshold by entomologists have emphasized this latter population level. The vast majority of pests do not have a crucial stage when they are vulnerable to pesticides; hence, the question of when to apply pesticides must be addressed. Indeed, the effectiveness of most pesticides is fairly well documented. The important issues are concerned with when they should be used.

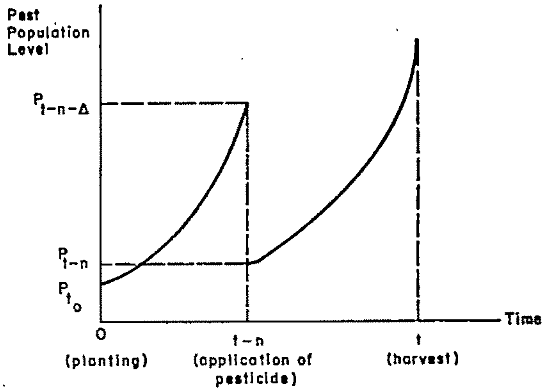

Figure 1. Pest population levels over time

Second, the cost of control must be a function of the level of population before controls are initiated, $P_{t-n-\Delta}$, and the difference between $P_{t-n-\Delta}$ and the level reached after control, P_{t-n}. Since $P_{t-n-\Delta}$ is a function of P_0, the pest population at the time of planting, Headley's cost function is valid only for a unique, unspecified value of P_0. It should be noted, furthermore, that, if the time of pesticide application $t-n$ is a variable, the cost function must be considerably respecified.

A Two-Variable Model

The following model corrects the above deficiencies yet retains as much as possible of the simple general form of Headley's model. It consists of five elements: a pest population growth function (equation 2.1), a pest population kill function (equation 2.2), a pest population damage function (equation 2.3), a product yield function (equation 2.4), and a pesticide cost function (equation 2.5). These are presented below.

Pest population growth and kill functions:

$$(2.1)\qquad P(t) = \begin{cases} P_0e^{rt} & \text{for } t_0 \le t \le t_i \\ (P_0e^{rt_i} - K)e^{r(t-t_i)} & \\ & \text{for } t_i < t \le t_h \end{cases}$$

$$(2.2a)\qquad K = K^*[X, P(t_i)] = K^*(X, P_0e^{rt_i})$$

$$(2.2b)\qquad K = K'(X, t_i, P_0, r)$$

where

r = pest population growth,
t_0 = planting time,
t_i = pesticide application time,

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[1] This assumption is not made clear in the original paper but is implicitly stated in a later letter from Headley to the authors dated February 3, 1972: "In fact, the population level P_{t-n} is entomologically determined as the *crucial state* of the insect" (*italics* ours).

t_h = harvest time,
K = pests killed by pesticide application,
P_0 = initial pest population at t_0,

and

X = quantity of pesticides.

The kill function indicates that the number of pests killed is a function of how much pesticide is applied and how many pests are present when the pesticide is applied. $P(t_i)$ is a function of t_i, r, and P_0; but, since the parameters P_0 and r are assumed to be fixed for any given planting period and pest, the abbreviation is as follows:

$$K = K(X, t_i). \tag{2.2c}$$

Pest population damage function:

$$d(t) = bP(t) \tag{2.3a}$$

$$D(t_2 - t_1) = \int_{t_1}^{t_2} d(t)dt \tag{2.3b}$$

where

$d(t)$ = instantaneous rate of crop damage in physical units due to pests (note that $d(t)$ is piecewise continuous over t_0 to t_h);
b = a parameter which specifies the rate of crop damage in physical units per pest;

and

$D(t_2-t_1)$ = cumulative crop damage between time t_1 and time t_2.

Total damage at harvest time can be broken into two parts, one before pesticide application and one after:

$$\begin{aligned} D(t_h - t_0) &= \int_{t_0}^{t_i} d(t)dt + \int_{t_i}^{t_h} d(t)dt \\ &= D_1 + D_2. \end{aligned} \tag{2.3c}$$

$$\begin{aligned} D(t_h - t_0) = \frac{b}{r}\{ &(e^{rt_h} - e^{rt_i}) \\ &\cdot [P_0 - e^{-rt_i}K(X, t_i)] \\ &+ P_0(e^{rt_i} - 1)\} \end{aligned} \tag{2.3d}$$

when $t_0 = 0$. This is derived by substitution of equations (2.1), (2.2c), and (2.3a) into equation (2.3c).[2]

Product yield function:

$$Y = N - D(t_h) \tag{2.4}$$

where

Y = physical yield at harvest,
$t_0 = 0$,

and

N = physical yield if no damage occurs from pests.

Pesticide cost function:

$$C = \alpha X \tag{2.5}$$

where

C = total cost of pesticides,
X = number of units of pesticides,

and

α = cost of purchasing and applying a unit of pesticide.

Profit can now be written:

$$\pi = \beta Y - C = \beta[N - D_1 - D_2] - \alpha X. \tag{2.6a}$$

Substituting equation (2.3c) into (2.6a) results in the following:

$$\begin{aligned} \pi = \beta N - \frac{\beta b}{r}\{ &(e^{rt_h} - e^{rt_i}) \\ &\cdot [P_0 - e^{-rt_i}K(X, t_i)] \\ &+ P_0(e^{rt_i} - 1)\} - \alpha X. \end{aligned} \tag{2.6b}$$

The economic threshold is the population level $P(t_i)$ associated with the two decision variables, the optimum application time t_i, and the optimum quantity of pesticide X, which simultaneously maximize profits. Differentiating equation (2.6b) with respect to X and t_i results in the first-order conditions:

$$\pi_X = -\alpha + \frac{\beta b}{r}[e^{r(t_h - t_i)} - 1]K_X(X, t_i) = 0. \tag{2.7a}$$

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[2] The pest population damage function may be rewritten as:

$$d(t) = \begin{cases} b[P(t) - A(t)] & \text{for } P(t) \geq A(t) \\ 0 & \text{for } P(t) \leq A(t) \end{cases}$$

where $A(t)$ is the pest damage tolerance level, the maximum pest population level which, at each point in time, results in no discernible loss due to pest damage at harvest time.

Two cases must be investigated. The first is whether P_0 is less than $A(t_0)$. The second is whether $P_0e^{rt_i} - K$ is less than $A(t_i)$. For simplicity, suppose A is constant. If $P_0 < A$, there exists some t_* such that equation (2.3d) may be rewritten as $P_0e^{rt^*} = A$ or $t_* = 1/r[ln(\text{A}) - ln(P_0)]$. Similarly, if $P_0e^{rt_i} - K$ is less than A, there exists some t_{**} such that $t_{**} = l/r[\ln(A) - \ln(P_0e^{rt_i} - K)] + t_i$.

Using equations (2.3) and (2.4), total damage can be broken into two periods consisting of damage before and after pesticide application: $D(t_h - t_0) = D[t_i - \max \cdot (t_*, t_0)] + D[t_h - \max(t_{**}, t_i)]$. The problem of applying the above equation is that the max (t_{**}, t_i) is not known *a priori*.

$$(2.7b)\quad \pi_{t_i} = [1 - e^{r(t_h - t_i)}]K_{t_i}(X, t_i) + re^{r(t_h - t_i)}K(X, t_i) = 0.$$

Equations (2.7a) and (2.7b) indicate that the economic threshold is also a function of the time of harvest, the rate of pest population growth, the rate of damage to crops per pest, the effectiveness of the pesticide, the cost of pesticide, and the price of the crop. Rewriting equations (2.7a) and (2.7b) results in the following:

$$(2.7c)\quad K_X(X, t_i) = \frac{\alpha r}{\beta b[e^{r(t_h - t_i)} - 1]}.$$

$$(2.7d)\quad K_{t_i}(X, t_i) = \frac{rK(X, t_i)e^{r(t_h - t_i)}}{e^{r(t_h - t_i)} - 1}.$$

Since t_h is greater than t_i in both case 1, condition 2, and case 2, $e^{r(t_h - t_i)} - 1$ is positive. Therefore, since α, r, β, and b are also positive, $K_X(X, t_i)$ is positive, indicating that more pesticide indeed kills more pests. Since $K(X, t_i)$ is positive for positive values of X, $K_{t_i}(X, t_i)$ is positive. This is intuitively appealing since, for later t_i's, the pest population density increases, and a fixed quantity of pesticide would kill a larger number of pests when the pest density is greater. It is rather interesting to note that product and pesticide costs affect K_X but not K_{t_i}. This means that, if the quantity of pesticides to be applied is for some reason fixed, the timing of application would not be affected by changes in the prices of the pesticide or the product. In this case the only determinants of t_i are the effectiveness of the pesticide and the pest population growth rate. To solve explicitly for the economic threshold, the form of the pest population kill function must be specified.[3]

Conclusions

The foregoing model is an improvement on Headley's model in that both the timing and the quantity of pesticide applied are variables. Like Headley's model, it provides rigor to the definition of the concept of economic threshold but is too simple for practical application. In reality, the decision to spray is complicated by the presence of more than one pest and interrelationships between pests, beneficial predators, and parasites which may also be killed by the pesticide. Furthermore, the toxicity of some pesticides is persistent; weather, pest density, and the availability of food, among other factors, influence net population growth rates; plants are sometimes more and other times less sensitive to pest damage; biological control inputs can be introduced into the system; and the system itself can be manipulated to reduce pest damage. Recent work by Carlson has brought out the importance of uncertainty and the risk preferences of pest managers [1]. As these additional factors are introduced, mathematical models rapidly become unmanageable.[4] "Black box" approaches, which explicitly recognize the uncertainty of future events and the risk preferences of the decision-maker, will be necessary in the next generation of models.

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[3] We note that profit maximization must be constrained to exclude negative pest populations and applications of negative quantities of pesticide. The second-order condition $\pi_{XX} < 0$ and the previous result $e^{r(t_h - t_i)} - 1 \geq 0$ imply that $K_{XX} < 0$. This means additional increments of pesticide must be less effective than previous increments. Summarizing, this model has a unique interior solution if the following three plausible assumptions are valid: the number of pests killed increases with an increase in the quantity of pesticide applied; the number of pests killed increases at a decreasing rate; and a given quantity of pesticide will kill more pests if the pest density increases.

[4] The mathematical complexity of the simple pest–predator relationship without the other factors discussed above has been explored recently by Paul A. Samuelson [4].

References

[1] CARLSON, GERALD A., "A Decision Theoretic Approach to Crop Disease Prediction and Control," *Am. J. Agr. Econ.* 52:216–223, May 1970.

[2] HEADLEY, J. C., "Defining the Economic Threshold," presented at the National Academy of Sciences, Symposium on Pest Control Strategies for the Future, Washington, D. C., April 15, 1971 (in National Academy of Science, *Pest Control Strategies for the Future*, 1972, pp. 100–108).

[3] National Research Council, Subcommittee on Insect Pests of the Committee on Plant and Animal Pests, "Insect Pest Management Control," *Principles of Plant and Animal Pest Control*, Ch. 17, Vol. 3, 1969.

[4] SAMUELSON, PAUL A., "Generalized Predator–Prey Oscillations in Ecological and Economic Equilibrium," *Proceedings of the National Academy of Sciences, U.S.A.* 68:980–983, May 1971.

The Optimum Combination of Resources Within and Among Country Elevators

P. W. LYTLE AND L. D. HILL

A sunk capital hypothesis and merger, analyzed with linear programming, are used as aggregate constraints to temper results of firm models when analyzing intermediate length–of–run structural adjustments of country elevators. The conflict of simultaneously recommending fewer firms in the industry and expansion of all individual firms is handled.

HISTORICAL data of changes in the structure of an industry often reveal a circuitous path leading slowly, if at all, toward the optimum size and type of firms identified in optimizing long–run models. The slow and sporadic response of individual firms to pressures for adjustment are partly explained by the cumulative effect on future decisions of past investments in facilities.

Prediction of the adjustment process of industry structure is hampered by the difficulty of incorporating market region constraints into the micro decision process of firms or models of these firms. Failure to recognize explicitly these constraints in micro decisions gives rise to two areas of inconsistencies: the sum of the volumes of individual firms that have expanded according to profit–maximizing micro models may exceed the potential volume available to the entire industry; and adjustments in the capacities and volumes of competing firms may change the coefficients on which the micro decisions were based.

In practice, marketing firms may risk additional resources for facility expansion and increased volume even when economic studies indicate an overcommitment of resources in the industry. In recent years published studies of industry structure suggest fewer and larger firms in many industries [2, 6, 7, 8, 10, 11, 13]. Typically, Chern and Polopolus determined that "... the current plant locations and plant numbers are excessive in relation to a long–run plan for industry efficiency in assembling and processing oranges in Florida. The findings suggest that merger, consolidation and possible abandonment of some old plants will be necessary in the future. On the other hand establishment of new plants in some new locations is also appropriate" [1, p. 585].

To reflect long–run equilibrium trends, the least-cost combination of resources should be based on full costs of invested capital. In the short–run adjustment process, however, industry structure depends on opportunity costs of capital invested in relatively fixed and often specifically designed assets, the noneconomic goals of management, and the economic variables that motivate change within individual firms. Within this transition process lie many important research questions and profit opportunities that can be analyzed with linear programming models.

Objectives and Procedures

The objective of the study was to analyze adjustments in the structure of the grain industry within a narrowly defined geographical region by testing alternative assumptions about the capital structure on the optimum number and types of elevators.

A basic linear programming model of all country elevators in an Illinois county was sequentially modified to provide solutions that determined: the optimum resource use and volumes for each firm in the market region given existing capacities and the opportunity to purchase additional facilities; the optimum volumes, resource combinations, and types of firms when all existing firms in the county compete for a given supply of grain and also when a potential entrant is included as an alternative; the effects of a sunk capital hypothesis; and the effects of a merger between two existing elevators.

Solutions for the individual firms (micro results) and for the market region as a whole (market region results) were compared using short–run managerial constraints and varying costs of capital to determine a possible adjustment process toward a long–run equilibrium organization of resources.

Market Region

Stark County, Illinois plus 10 adjacent townships comprised the market region to be

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Table 1. Projected actual volumes during the 1975–1976 crop year and other characteristics of the firms

Item	Firm								
	1	2	3	4	5	6	7	8	9
Farmer-owned corn T_1-T_4* (1,000 bu.)	109	None	None	415	945	267	315	None	None
Elevator-owned corn T_1-T_4* (1,000 bu.)	182	276	486	204	236	267	210	318	263
Grain bank T_1-T_4* (1,000 bu.)	73	None	None	None	None	None	None	6	66
Farmer-owned soybeans T_1-T_4* (1,000 bu.)	7	None	None	33	50	16	13	None	None
Elevator-owned soybeans T_1-T_4* (1,000 bu.)	16	54	66	67	12	62	38	40	30
Period 5 volume (1,000 bu.)	1,160	359	197	824	1,710	245	736	335	247
Total corn T_1-T_5** (1,000 bu.)	1,283	612	681	1,272	2,187	772	1,241	589	544
Total soybeans T_1-T_5** (1,000 bu.)	264	78	68	271	766	84	70	110	62
Total grain handled T_1-T_5** (1,000 bu.)	1,547	689	749	1,543	2,953	856	1,311	699	606
Dries corn	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Willing to expand	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Present storage capacity (1,000 bu.)	264	57	49	350	502	661.5	85	45	150
Present drying capacity (bu./hr.)	417	—	1,222	695	1,136	625	—	833	357

* T_1-T_4 refers to time periods one through four.
** T_1-T_5 refers to time periods one through five.

analyzed. The region was selected on the basis of two main criteria: the potential demand for services of country elevators; and evidence of required adjustments in existing facilities to meet the demand for these services [5].

Micro Analysis

Structure of the micro models

Micro models were constructed using the resources, demand for services, supplies of grain, and managerial constraints appropriate to each firm in the market region. This information was determined through personal interviews with managers of the firms and from secondary data [9].

The micro model of each firm was basically the same and permitted the firm to:

(1) Receive, dry, store, and ship corn and soybeans.
(2) Hire labor and expand existing receiving, drying, storage and/or shipping capacity at varying costs of capital.
(3) Differentiate among farmer–owned and elevator–owned corn and soybeans, and grain-bank corn.
(4) Operate during five time periods representing three consecutive one day periods of maximum harvest receipts (T_1-T_3), the remainder of harvest through December (T_4), and the remainder of the crop year (T_5).
(5) Earn merchandising margins of 3, 2, or 1 cent per bushel for corn and 4, 3, or 2 cents per bushel for soybeans; the margins vary according to degree of competition among firms to obtain additional volumes [14, pp. 958–959].

Supplies of grains were based on projections of marketings to 1975 and made available to each micro model for each of the five time periods according to each firm's historical receipts pattern. Projected actual volumes, characteristics, and model restrictions of the nine elevators in the market region are summarized in Table 1.

Solutions for the micro models

Table 2 summarizes the results of the profit–maximizing micro solution for each firm. In general the firms received enough grain to meet their storage capacity restrictions plus all the highest margin grain available in T_4, much of which was shipped immediately after it was received.

Comparisons of the optimum volumes in Table 2 with the projected volumes in Table 1 reveal that all nine firms could increase profit by increasing the volume handled even over actual projected volumes. At the 7 percent cost of capital used to obtain the values in Table 2, Firms 1, 4, 5, and 6 purchased additional drying capacity.

Parametric programming on the micro models

The cost coefficients and thus the micro solutions could be altered by individual firms through a recombination of resources or through changes in volume and capacity. To test the sensitivity of the nine firms to changes in their costs, parametric programming was used on

Table 2. Volumes handled in each micro solution at 7 percent cost of capital

Item	Firm 1	2	3	4	5	6	7	8	9
Objective function ($1,000)	107	30	13	56	77	51	35	12	18
Farmer-owned corn T_1-T_4* (1,000 bu.)	187	—	—	508	921	491	—	—	—
Elevator-owned corn T_1-T_4* (1,000 bu.)	331	520	392	250	230	491	401	452	413
Grain bank T_1-T_4* (1,000 bu.)	125	—	—	—	—	—	—	2	56
Farmer-owned soybeans T_1-T_4* (1,000 bu.)	—	—	—	22	—	11	38	—	—
Elevator-owned soybeans T_1-T_4* (1,000 bu.)	44	114	57	46	65	45	113	29	45
Period 5 volume (1,000 bu.)	3,726	1,262	2,845	3,722	1,815	3,055	3,059	3,722	706
Total corn T_1-T_5** (1,000 bu.)	3,617	1,700	3,216	3,732	2,219	3,956	3,376	3,428	1,082
Total soybeans T_1-T_5** (1,000 bu.)	791	196	78	815	812	136	235	776	136
Total grain handled T_1-T_5** (1,000 bu.)	4,409	1,896	3,294	4,547	3,031	4,093	3,611	4,204	1,219
Storage capacity (1,000 bu.)	264	57	49	350	502	661.5	85	45	150
Drying capacity (bu./hr.)	549	—	1,222	861	1,311	959	—	833	357

* T_1-T_4 refers to time periods one through four.
** T_1-T_5 refers to time periods one through five.

each of the nine models to analyze changes in facility purchases for costs of capital from 10 to 0 percent. Capital costs were selected because they provide a convenient coefficient affecting all activities simultaneously and can serve as a proxy for changes in other cost items.

Purchases of storage capacity were relatively insensitive to reductions in capital costs. At a low 3 percent cost of capital, Firms 1, 3, 4, and 5 added small amounts of storage; all firms except Firm 6 added minimal storage capacity with further reductions to zero cost of capital. Drying and receiving capacity purchases were also minimal until the cost of capital became 3 percent or less.

The micro solutions exhibited a high degree of stability in their profit–maximizing combination of resources, particularly at interest rates around the base value of 7 percent. Increases in efficiency, changes in cost structure, or variability in minimum levels of returns to capital would be expected to have little effect on the actions of firms already established in the market region.

Aggregative Adjustments of Existing Firms

The general recommendation for each firm based on the micro solutions would be a reduction of margins when possible in order to expand the quantity of grain handled. However, if all firms in the region attempted to follow this recommendation, their aggregated demands for corn and soybeans from harvest through December (T_1–T_4) would exceed the total estimated supply of 4,944,000 bushels by over 1,453,000 bushels. Most of the nine firms would be operating on a reduced merchandising margin for at least part of the crop year under the assumption that these higher prices would elicit larger volumes. Those firms for which additional volume failed to materialize would suffer reduced incomes. The long-run effect would be elimination of financially weaker firms and additional profit opportunities for the survivors. Knowledge of which firms should, or will, survive would facilitate the adjustment process and lessen the economic losses to firms and society. The market region models provided additional insight into this adjustment process.

The basic structure of each market region model was a combination of the micro models into a single matrix. Common row constraints were used for each market region supply of the different classes of grain; only T_1–T_4 supplies were used because all T_5 volumes are shipped from farms to subterminal elevators. There was no differentiation of merchandising margins so that each elevator competed on the basis of its efficiency in performing necessary functions. The solutions of these models identify the cost minimizing combination of elevators and their respective activities.

Basic market region model

To evaluate the adjustment process by which the existing nine firms in Stark County in competition with each other will move toward optimum organization for the industry, a market region model was solved using the present capacities and restrictions of each firm including the opportunity for additional facility investment at an interest rate of 7 percent. Cost advantages, diversity of services offered, grain handling efficiency, and flexibility of

Table 3. Volumes handled in basic market region solution

Cost of capital	Firm 1 corn	Firm 2 corn	Firm 2 soybeans	Firm 3 corn	Firm 4 corn	Firm 4 soybeans	Firm 5 corn	Firm 6 corn	Firm 7 soybeans	Firm 8 corn	Firm 9 corn	Firm 9 soybeans
(Percent)	1,000 Bushels											
10	623	179	114	147	711	195	1,151	1,229	170	100	301	24
9	623	179	114	147	711	195	1,151	1,229	170	100	301	24
8	623	179	114	147	711	195	1,151	1,229	170	100	301	24
7	623	179	114	147	711	195	1,151	1,229	170	100	301	24
6	623	179	114	147	711	195	1,151	1,229	170	100	301	24
5	623	177	114	147	1,131	—	1,151	1,024	170	100	88	219
4	623	175	114	147	1,177	—	1,151	1,024	129	100	43	261
3	593	176	86	147	1,206	156	1,151	1,024	—	100	43	261
2	593	175	87	147	1,207	156	1,151	1,024	—	100	43	261
1	593	175	—	147	1,207	432	1,151	1,024	—	100	43	72
0	593	176	—	147	1,206	503	1,151	1,024	—	100	43	—

management were the factors that differentiated the firms with respect to opportunity to grow or even survive.

Volumes handled by the firms in the basic market region solution varied significantly from their respective micro results although all nine firms remained viable (compare Table 2 with the 7 percent interest basic market region solution of Table 3). In general the firms reduced receipts in the market region solution relative to their micro solutions because of the fixed supply available to the market region. Reduced volumes indicate that the results of micro level analyses must be tempered with aggregative constraints.

Parametric programming on the cost of capital for all firms revealed significant changes in volumes handled and provided additional information on the expansion opportunities and the competitive advantages of the nine firms (Table 3). All firms except Firms 7 and 9 expanded at least one phase of their physical plant to meet the demand for services in the market region as interest rates varied.

Long-run optimum market region model—all resources variable

Examination of the long-run optimum organization of the industry requires a model in which all resources are variable and the types of firms are not restricted to those presently operating in the region. A large, highly mechanized grain elevator (called Firm A) was included as an alternative in the second market region model, along with the elevator types represented by the existing nine firms. All firms started with no capital facilities and could purchase equipment at a 7 percent cost of capital. Fixed costs were calculated on a per bushel basis and were adjusted if a firm entered the solution at a significantly different size than assumed in the original budgeting. Firm A dominated the outcome due to its lower operating costs. Firm 2 was the only other firm in the optimal solution; it was strictly a merchandising and blending operation.

Simultaneously changing the interest rates for all firms (the equivalent of changes in costs for fixed facilities) did virtually nothing to offset the efficiency advantage of Firm A and merchandising advantage of Firm 2. This kind of result is often cited as evidence that large, highly mechanized, efficient grain handling facilities will dominate the structure of the country elevator industry as the long-run optimum structure is approached. Such a conclusion may be valid when all facilities must be purchased at the full cost of capital, but the observed low rate of decrease in numbers of firms in the industry suggests that other models are needed to explain the adjustment process.

The sunk capital hypothesis

Most elevator facilities in the county are depreciated nearly to zero, and there are no alternative uses for the invested capital. Consequently, these firms may realistically ignore depreciation costs except on purchases of new equipment while construction of a new firm would require full cost for all facilities plus a competitive return on capital.

The market region model testing the sunk capital hypothesis used present capacity of each existing firm, but no interest or depreciation charge was included for use of this capacity. Any addition of new capacity to the existing facilities incurred full costs of depreciation and a 7 percent interest charge. Firm A could enter

Table 4. Volumes handled in the market region solution of the sunk capital hypothesis

Cost of capital to Firm A	Firm A corn	Firm 1 corn	Firm 1 soybeans	Firm 2 corn	Firm 2 soybeans	Firm 3 corn	Firm 4 corn	Firm 4 soybeans	Firm 5 corn	Firm 6 corn	Firm 7 soybeans	Firm 8 corn	Firm 9 corn	Firm 9 soybeans
(Percent)							1,000 Bushels							
20	—	623	—	179	114	147	711	195	246	1,229	170	100	301	240
19	353	623	—	172	114	147	783	—	1,151	1,024	170	100	88	219
18	353	623	—	172	114	147	783	—	1,151	1,024	170	100	88	219
17	353	623	—	172	114	147	783	—	1,151	1,024	170	100	88	219
16	400	623	—	169	114	147	783	—	1,151	1,024	129	100	43	261
15	429	593	—	170	114	147	783	—	1,151	1,024	129	100	43	261
14	604	593	—	167	89	147	611	154	1,151	1,024	—	100	43	261
13	604	593	—	167	89	147	611	154	1,151	1,024	—	100	43	261
12	604	593	—	167	89	147	611	154	1,151	1,024	—	100	43	261
11	669	593	—	166	32	147	548	210	1,151	1,024	—	100	43	261
10	678	593	—	166	25	147	539	218	1,151	1,024	—	100	43	261
9	679	593	—	166	24	147	538	219	1,151	1,024	—	100	43	261
8	680	593	—	164	24	147	527	219	1,151	1,024	—	100	43	261
7	699	593	—	163	—	147	511	243	1,151	1,024	—	100	43	261
6	1,506	593	—	151	—	147	224	500	1,151	526	—	100	43	3
5	1,983	590	3	129	—	147	224	500	1,151	75	—	100	43	—
4	2,177	590	3	129	—	147	224	500	957	75	—	100	43	—
3	3,037	590	3	114	—	123	224	500	136	75	—	99	43	—
2	3,184	443	3	114	—	133	224	500	136	75	—	99	43	—
1	3,600	50	—	114	—	109	220	503	136	75	—	99	38	—
0	3,776	50	—	114	—	109	52	503	136	75	—	99	29	—

the solution only by purchasing all facilities and equipment and covering both fixed and variable costs. Capital costs to Firm A were varied from 20 to 0 percent, and the resulting solutions (Table 4) revealed the tenacity of existing firms and partially explained the relatively slow decline in the number of grain plants in Illinois.[1]

Comparisons of the micro and market region solutions at a 7 percent cost of capital revealed the following: the micro solutions (Table 2) were more consistent with the results of the sunk capital hypothesis (Table 4) than with the results of the long-run optimum model; and if existing firms ignore returns to invested capital, all except Firm 7 can at least survive even if Firm A attempts to penetrate the market. Given the actual tenacity of the firms in the market region, these conclusions imply that the results of the sunk capital hypothesis are appropriate constraints on micro decisions about firm adjustments in approaching the long-run optimum industry structure.

Cost of capital (or returns on investment) required for Firm A had a significant effect on its competitive role in the structural adjustments of the region. At returns to capital of 7 percent or above, the existing firms maintained their relative positions in the market. At 7 percent the size of Firm A was responsive to changes in the cost of capital, and further interest rate reductions increased the volumes handled by Firm A although Firm 4 continued to be competitive in handling soybeans. Facilities purchased by Firms 1–9 were insignificant at all interest rates.

Although these changes resulted from lower interest rates for Firm A, similar changes could be induced by raising fixed costs for the other nine firms by a comparable amount. Considerable divergence would be required between returns on new and old capital to maintain the present market structure status quo. However, if a potential new firm, like Firm A, makes the judgment that it would not build unless it received a minimum of 15 percent return on investment, even Firm 7 could survive.

Sunk capital hypothesis with merger

One of the most frequently recommended actions in market regions with underdeveloped, inefficient firms is the merger of existing firms to create an economically viable operation [3, 4, p. 1497]. Firm Z represents a merger between Firms 1 and 7 in the fourth market region model. Revised cost coefficients were determined using the combined facilities, and the two managers were reduced to one. Firm A was required to build all facilities at costs of capital ranging from 20 to 0 percent. Firms Z, 2, 3, 4, 5, 6, 8, and 9 started with their existing capacities and were permitted to build new facilities at a 7 percent cost of capital.

Firm A's advantage was reduced by the merger relative to the solution of the sunk capital hypothesis (compare Tables 4 and 5) as evidenced by reduced volumes for all different capital costs (returns on investment).

Merger also resulted in advantages for both Firms 1 and 7. Firm Z had a net gain in volume

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[1] The number of commercial storage plants in Illinois has shown a net decrease of approximately five plants per year over the past 10 years despite research results indicating an optimum number far less than the 1,478 reported on January 1, 1971 [12, p. 67].

Table 5. Volumes handled in the market region solution of the sunk capital hypothesis with a merger

Cost of capital to Firm A	Firm A corn	Firm Z corn	Firm Z soybeans	Firm 2 corn	Firm 2 soybeans	Firm 3 corn	Firm 4 corn	Firm 4 soybeans	Firm 5 corn	Firm 6 corn	Firm 8 corn	Firm 9 corn	Firm 9 soybeans
(Percent)							1,000 bushels						
20	—	1,199	—	164	90	147	612	153	1,151	1,024	100	43	261
19	—	1,199	—	164	90	147	612	153	1,151	1,024	100	43	261
18	—	1,199	—	164	90	147	612	153	1,151	1,024	100	43	261
17	—	1,199	—	164	90	147	612	153	1,151	1,024	100	43	261
16	—	1,199	—	164	90	147	612	153	1,151	1,024	100	43	261
15	—	1,199	—	164	90	147	612	153	1,151	1,024	100	43	261
14	—	1,199	—	164	90	147	612	153	1,151	1,024	100	43	261
13	—	1,199	—	164	90	147	612	153	1,151	1,024	100	43	261
12	414	784	—	165	90	147	612	153	1,151	1,024	100	43	261
11	478	784	—	164	34	147	549	209	1,151	1,024	100	43	261
10	488	784	—	164	25	147	539	218	1,151	1,024	100	43	261
9	489	784	—	164	24	147	538	219	1,151	1,024	100	43	261
8	515	758	24	164	—	147	538	219	1,151	1,024	100	43	261
7	516	758	24	163	—	147	538	219	1,151	1,024	100	43	261
6	1,318	757	24	151	—	147	247	480	1,151	1,024	100	43	—
5	1,791	757	24	129	—	147	247	480	1,151	75	100	43	—
4	1,986	757	24	129	—	147	247	480	957	75	100	43	—
3	2,845	704	72	114	—	125	300	432	136	75	99	43	—
2	2,846	757	24	114	—	123	247	480	136	75	99	43	—
1	2,846	757	24	114	—	123	247	480	136	75	99	43	—
0	3,364	443	304	114	—	113	53	200	136	75	99	43	—

handled and purchased more drying and storage capacity than the sum of purchases by Firms 1 and 7 when included as separate firms. Although the merger enabled use of the facilities of Firm 7, Firm A still handled the majority of the available supply of grain at returns to capital of 6 percent and below. However, these returns are possibly too low to attract the capital necessary to permit a firm like Firm A to begin operations.

Implications

This study revealed with quantitative evidence that typical models of the firm must be tempered with aggregate constraints. In the micro solutions the total volume handled from harvest through December exceeded total supply in the market region by over 1.4 million bushels. Integration of market region constraints into micro decision processes provides an improved predictive tool for making intermediate length-of-run projections about adjustments in the structure of the industry and by individual firms.

Comparisons of the micro results and the market region results under the sunk capital hypothesis justify the following conclusions about individual firms:

(1) An elevator like Firm A probably will not build in the county due to the necessity of covering all costs and the potentially low returns to investment.

(2) There are strong economic incentives for a merger of Firms 1 and 7, although noneconomic factors may discourage the action.

(3) Good management is the key to the survival of Firm 2. Firm 2 acting only as a merchandiser seems vulnerable to competition that could result in reduced corn receipts, but the firm may be able to increase soybean receipts.

(4) Only Firms 5 and 6 have economic potential as specialized corn merchandisers with volumes above 1 million bushels.

(5) Under conditions of severe competition (e.g., if Firm A were to accept returns of 5 percent on its investment and Firms 1 and 7 did not merge), only Firms 1, 3, 4, and 5 will remain viable units, although the grain banking services of Firms 8 and 9 will extend their economic life.

The market region results also suggest a need for change in analyzing the probable structure of the country elevator industry and probably other industries. Solutions from the sunk hypothesis along with merging two of the nine existing firms reduced the ability of potential Firm A to compete for business in the market region except at returns to capital below 7 percent, a return probably too low to attract a new firm to the area.

Inclusion of competitive techniques and managerial restrictions in the models adds realism to the solutions which in turn enhances the recommendations to managers of the firms. And importantly, the approach of this study can handle the micro-market region conflict of recommending expansion to each individual firm while recommending contraction to the industry as a whole.

References

[1] Chern, Wen-Shyong, and Leo Polopolus, "Discontinuous Plant Cost Function and a Modification of the Stollsteimer Location Model," *Am. J. Agr. Econ.* 52:581–586, Nov. 1970.

[2] Cobia, D. W., and E. M. Babb, "An Application of Equilibrium Size of Plant Analysis to Fluid Milk Processing and Distribution," *J. Farm Econ.* 46:109–116, Feb. 1964.

[3] Garoian, Leon, and Gail L. Cramer, "Merger Component of Growth of Agricultural Cooperatives," *Am. J. Agr. Econ.* 50:1472–1482, Dec. 1968.

[4] Helmberger, Peter, "Firm Mergers and General Welfare," *Am. J. Agr. Econ.* 50:1485–1498, Dec. 1968.

[5] Hill, L. D., *Adequacy of Elevator Capacity in Illinois Counties*, University of Illinois Coop. Ext. Service Cir. 1015, March 1970.

[6] King, Gordon A., and Samuel H. Logan, "Optimum Location, Number and Size of Processing Plants with Raw Product and Final Product Shipments," *J. Farm Econ.* 46:94–108, Feb. 1964.

[7] Ladd, George W., and M. Patrick Halvorson, "Parametric Solutions to the Stollsteimer Model," *Am. J. Agr. Econ.* 52:578–580, Nov. 1970.

[8] Polopolus, Leo, "Optimum Plant Numbers and Locations for Multiple Product Processing," *J. Farm Econ.* 47:287–295, May 1965.

[9] Schids, David A., "An Analysis of Corn Drying and Corn Storage Cost for the Farm and for the Elevator," unpublished M.S. thesis, Southern Illinois University, 1967.

[10] Stollsteimer, John F., "A Working Model for Plant Numbers and Locations," *J. Farm Econ.* 45:631–645, Aug. 1963.

[11] Toft, H. I., P. A. Cassidy, and W. O. McCarthy, "Sensitivity Testing and the Plant Location Problem," *Am. J. Agr. Econ.* 52:403–410, Aug. 1970.

[12] von Oppen, M. K., "Number, Size and Location of Grain Storage Facilities in Illinois," unpublished M.S. thesis, University of Illinois, 1969.

[13] Warrack, Allan A., and Lehman B. Fletcher, "Plant-Location Model for Suboptimization for Large Problems," *Am. J. Agr. Econ.* 52:587–590, Nov. 1970.

[14] Williamson, J. C., "The Equilibrium Size of Marketing Plants in a Spatial Market," *J. Farm Econ.* 44:953–967, Nov. 1962.

Econometric Models for Quarterly Shell Egg Prices*

Sujit K. Roy and Phillip N. Johnson

Relationships determining shell egg prices were analyzed by developing models involving a simultaneous equation system estimated by using the three-stage least squares method. The findings substantiated the postulated relations including the interdependency of the shell egg and breaking egg sectors. Price estimates generated from the models appeared acceptable.

The U. S. egg industry has undergone substantial changes in recent years. Growing importance of the breaking egg sector, increasing commercialization and integration of the production and marketing operations, and continuing technological improvements in the production process have produced a considerable impact on the price-determining process. The objective of the present study was to develop econometric models for quarterly wholesale shell egg prices to provide a quantitative analysis of the current market relationships which determine such prices. The models were also designed to predict egg prices for the succeeding quarter.

The Basic Model

The postulated model contained the following seven equations including two identities and five stochastic relations:

(1) $Q_t = f(P_t, I_t, T)$

(2) $Q_t = Y_t - H_t - B_t$

(3) $B_t = f(P_t/P_{t-1}, PF_{t-1}, SF_{t-1}, B_{t-1}, T)$

(4) $Y_t = (\bar{L}_t \times E_t/100) \div 12$

(5) $\bar{L}_t = f[L_{t-1}, (R_{t-2} + R_{t-3}), (R_{t-6} + R_{t-7})]$

(6) $E_t = f(E_{t-1}, T)$

(7) $H_t = f(PB_{t-1}, P_{t-1}/P_{t-5}, T)$

where

t = current calendar quarter and $(t-i)$ relates to the lagged time period;
Q = aggregate consumption of shell eggs during the quarter derived from the identity, equation (2), million dozen;
P = simple average of daily wholesale prices at Chicago, 80 percent Grade A large eggs, during the quarter, cents per dozen;
I = disposable consumer income, seasonally adjusted annual rates for the quarter, billion dollars;
T = time variable, where $T=1$ for 1961, $T=2$ for 1962, etc.;
Y = total shell egg production during the quarter, million dozen;
B = quantity of eggs used for commercial breaking during the quarter, million dozen;
H = quantity of eggs used for hatching during the quarter, million dozen;
E = number of eggs laid per 100 layers during the quarter;
$\bar{L}$ = average number of layers on hand during the quarter, million;
L = number of layers on hand on the first day of the quarter, million;
PF = average price of frozen whole egg, light colored, at New York during the quarter, cents per pound;
SF = all frozen eggs in storage on the first day of the quarter, million pounds;
R = number of chicks placed for laying flock replacements during the quarter, million;
PB = average price of U. S. and plant Grade A broilers at Chicago during the quarter, cents per pound;

Consumption of shell eggs, as presented in equation (1), is dependent on the price of shell eggs and disposable income. The effect of prices of competing and complementary products on the consumption of shell eggs was assumed to be insignificant, this assumption being based on the statistical findings of earlier studies [2, pp. 70–71; 3, pp. 49, 52].

Net storage movements, government purchases, and net exports of shell eggs during the period were not allowed for separately in the identity, equation (2), since these items comprise only a minor portion of total shell egg

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supply. For instance, an average of about 2.5 percent of shell egg supply was accounted for by these three items during 1961–1969 [5].

The amount of eggs broken for commercial use, as presented in equation (3), was hypothesized to be inversely related to current shell egg prices. The carry-over of frozen eggs in storage from the preceding quarter, SF_{t-1}, may be expected to affect inversely the quantity of eggs broken during the quarter. Furthermore, decisions regarding the quantity of shell eggs to be broken during the quarter was assumed to depend on the knowledge of frozen egg prices during the most recent past, i.e., PF_{t-1}.

Production of shell eggs during a given quarter, as described in an identity, equation (4), is the product of the average number of layers on farms, $\bar{L}_t$, and the number of eggs per layer, $E_t/100$, during the quarter. Division by 12 is required to convert the number to dozens. This identity, in its turn, necessitated the introduction of equations (5) and (6) which yield estimates of $\bar{L}_t$ and E_t. The average number of layers on farms during the quarter is primarily determined by the number of layers on farms at the beginning of the period, L_t, the number of chicks which enter the laying flock, and the number of older hens withdrawn from the flock during the quarter. The number of layers on the first day of the current quarter, L_t, is in fact unknown at the beginning of the period. Hence L_t was substituted by the number of layers at the beginning of the preceding quarter, i.e., L_{t-1}, in equation (5). Pullets generally reach laying age in about six months and remain productive till the age of 18 months. It was therefore assumed that the number of young hens entering the laying flock during the current quarter and the preceding quarter would be approximately represented by the number of chicks placed for layer replacements two and three quarters ago, $(R_{t-1}+R_{t-3})$. Similarly, the number of older hens leaving the laying flocks during the current quarter and the preceding quarter may be estimated by the number of chick replacements six and seven quarters ago, $(R_{t-6}+R_{t-7})$.

Layer productivity has consistently increased during the past several years; hence the number of eggs per layer, E_t, in equation (6) was expressed as a function of time. The lagged value of the variable, E_{t-1}, was also included to represent the most recent level of layer productivity.

Quantity of eggs used for hatching, H_t, depends primarily on the cost–return relationships in the shell egg and broiler industries. It was initially assumed that the egg–feed price ratio and the broiler–feed price ratio for the preceding quarter would serve as prime indicators of such return–cost relationships. However, least squares estimates of equations involving lagged values of egg–feed and broiler–feed price ratios produced inconsistent and insignificant coefficients for these variables in relation to hatching activities. This necessitated the present formulation of the function, as presented in equation (7) in which lagged egg prices and broiler prices as such are the major explanatory variables. No attempt was made to develop a complete structural specification for the hatching egg sector which by itself may involve one or more multi–equation models of supply and demand. The equation for hatching egg quantity was introduced into the model for the sole purpose of estimating this quantity during the quarter.

Statistical Procedures and Results

The stochastic relations, equations (1) and (3), and the identity, equation (2), comprise a simultaneous equation system including three endogenous variables, Q_t, P_t, and B_t. Equations (4), (5), (6), and (7) were considered as independent of the simultaneous equation system. Consequently two basic variables, Y_t and H_t, were postulated as predetermined variables relative to the simultaneous equation system. The latter four equations were introduced to develop the model as a closed system for prediction of prices one quarter ahead. Direct least squares estimates were obtained for equations (5), (6), and (7), since these are independent equations in the model and each involves only a single dependent variable. The stochastic relations in the simultaneous equation system, i.e., equations (1) and (3), were estimated by use of the three–stage least squares method.

Data for the 9–year period 1961–1969 were used to estimate structural relations in the models. Data on daily wholesale prices of shell eggs, reported by the USDA [4], were obtained from [1]. The disposable consumer income series is published by [7]. Time–series data for all other variables in the models were obtained from [5, 6].

A separate model was developed for each of the four calendar quarters to allow for seasonal characteristics of quarterly data. The price of shell eggs, P_t, was treated as the dependent variable in the first–round equations subsequently used to develop the three-stage least squares estimates of equations (1) and (3). Statistical estimates of the five stochastic relations in the model for each quarter are presented in Tables 1, 2, 3, 4, and 5.

Results of the consumption-price equation (1), Table 1, indicate that the signs of the coefficients are consistent with the expected causal relations. The hypothesized relations in the breaking egg use equation (3) have been substantiated by the results presented in Table 2. Most of the coefficients were also significantly different from zero at the 5 or 10 percent significance level. Inconsistency of signs and statistical insignificance led to the exclusion of one or two variables from the equations for the first and third quarters. The postulated inverse relation between the shell egg price ratio, P_t/P_{t-1}, and eggs used for breaking, B_t, has been confirmed by the results. Furthermore, the related parameters for each quarter except the third are highly significant. An important aspect of the results of equations (1) and (3) is the confirmation of the postulated relation between the shell egg and breaking egg sectors. Simultaneity in the determination of net supply of shell eggs, Q_t, eggs used for breaking, B_t, and shell egg price, P_t, as evidenced in the present study, ought to be recognized in any realistic

Table 1. Three-stage least squares equations for consumption of shell egg, Q_t, equation (1)

Quarter	Constant term	Regression coefficients of		
		P_t	I_t	Log T'[a]
I	4133	−3.575 (1.201)[b]	.8111 (.2918)	−1770 (1445)
II	−2247	−3.998 (.9235)	.1642 (.2131)	1897 (1073)
III	−108.4	−2.432 (.6585)	.3949 (.2351)	636 (1201)
IV	635.6	−2.319 (.7323)	.2314 (.3511)	1001 (1781)

[a] T' represents time where $T' = 61, 62, \ldots$

[b] Numbers in parentheses are the standard errors of regression coefficients.

Table 2. Three-stage least squares equations for eggs used for breaking, B_t, equation (3)

Quarter	Constant term	Regression coefficients of				
		P_t/P_{t-1}	PF_{t-1}	SF_{t-1}	B_{t-1}	T
I	232.9	−167.4 (18.9)	−.9902 (.5175)	—	.8985 (.1072)	−3.133 (1.042)
II	439.1	−205.0 (31.2)	−2.679 (.961)	−.0269 (.1591)	.3101 (.1079)	−6.797 (.742)
III	54.5	− 55.05 (51.41)	—	—	.5139 (.2194)	7.530 (1.664)
IV	151.6	− 80.44 (20.20)	—	−.4904 (.1225)	.3339 (.1689)	4.229 (1.391)

Table 3. Ordinary least squares equations for average number of layers $\overline{L}_t$[a], equation (5)

Quarter	Constant Term	Regression coefficients of			R^2	SEE[b]
		L_{t-1}[a]	$(R_{t-2}+R_{t-3})$[a]	$(R_{t-6}+R_{t-7})$[a]		
I	.1164	1.092 (.155)	.0299 (.0789)	−.1832 (.0917)	.934	.00377
II	.6092	.6806 (.1265)	.0983 (.0289)	−.0146 (.0215)	.970	.00299
III	−.2829	1.062 (.374)	.0902 (.0783)	−.0346 (.0810)	.962	.00339
IV	−.2357	.9341 (.0798)	.2347 (.0309)	−.0473 (.0263)	.974	.00208

[a] Expressed in logarithms of actual values.

[b] Standard error of estimate.

Table 4. Ordinary least squares equations for the number of eggs per 100 layers, E_t^a, equation (6)

Quarter	Constant Term	Regression coefficients of E_{t-1}^a	Regression coefficients of T	R^2	SEE
I	.8464	.7793 (.2939)	−.00197 (.00186)	.741	.00608
II	1.729	.5459 (.1864)	−.00128 (.00070)	.589	.00409
III	.0286	.9956 (.0225)	.00342 (.00005)	.999	.00035
IV	−.6197	1.162 (.166)	.00056 (.00067)	.976	.00259

[a] Expressed in logarithms of actual values.

study of the supply and demand structure of the egg industry.

Comparable estimates of equations (1) and (3) were also obtained with all variables relating to quantity and income expressed in per capita terms. These alternative equations in some cases yielded coefficients with signs contrary to economic logic. Furthermore, calculated prices developed from these equations for each quarter were considerably less accurate than those derived from the equations presented here.

The ordinary least squares estimates of the logarithmic equations for the average number of layers on farm, $\bar{L}_t$, equation (5), as presented in Table 3, yielded superior results in terms of statistical tests as well as predictive accuracy over similar equations formulated in linear terms. The two lagged replacement variables, $(R_{t-2}+R_{t-3})$ and $(R_{t-6}+R_{t-7})$, representing the addition of new layers and withdrawal of older hens respectively, have generated signs which are consistent with the hypotheses. The ordinary least squares equations for layer productivity, E_t, equation (6), Table 4, yielded better results, especially in terms of prediction, for the last two quarters than those for the first two. Layer productivity of the preceding quarter, E_{t-1}, appeared to be the main predictor in all cases.

The lagged prices of shell eggs and/or broilers, P_{t-1}/P_{t-5} and/or PB_{t-1} respectively, in the final formulation of equation (7) as presented in Table 5 yielded relations which are consistent with the initial specifications. The hatching egg use equation (7) in the present model is likely an oversimplified formulation. Yet the three explanatory variables have performed adequately in explaining variations in the dependent variable, especially for the last three quarters of the calendar year.

An equation for net storage movements of shell eggs was included in the simultaneous equation system in an initial formulation. But inconsistent signs and statistical insignificance of the coefficients, and large prediction errors led to its omission from the model. Apparently storage of shell eggs in recent years has lost its significance in the price determination process in the shell egg sector.

Price forecasts were developed for all quarters within the sample period from the reduced form price equations which were algebraically derived from the simultaneous equation system, equations (1), (2), and (3). Predicted values of Y_t and H_t based on equations (4), (5), (6), and (7) were used in the reduced form price equations to obtain price estimates. The model for the second quarter yielded the most accurate forecasts, while the model for the fourth quarter produced the largest overall magnitude of prediction errors. Alternative estimates of equations (1) and (3) were also obtained by use of the two-stage least squares method. Price fore-

Table 5. Ordinary least squares equations for the number of eggs used for hatching, H_t, equation (7)

Quarter	Constant term	Regression coefficients of PB_{t-1}	Regression coefficients of P_{t-1}/P_{t-5}	Regression coefficients of T	R^2	SEE
I	76.83	—	10.097 (4.168)	1.208 (.443)	.669	3.418
II	39.20	1.359 (.706)	2.976 (3.498)	2.716 (.266)	.960	1.969
III	17.73	1.522 (.689)	—	3.326 (.454)	.971	2.282
IV	29.57	1.032 (.682)	3.088 (5.497)	3.411 (.575)	.967	2.717

casts based on these equations were generally less accurate than the forecasts obtained from the three–stage least squares equations.

Summary and Conclusions

Results of the seven–equation quarterly models for wholesale shell egg prices indicated that all estimated relations were consistent with economic or logical expectations. Price forecasts developed from the models appeared to be satisfactory, especially for the first three quarters of the calendar year. Methodologically, price forecasts based on three–stage least squares equations were more accurate than those developed from the corresponding two–stage least squares equations.

A basic feature of the present study is the postulated interdependency of the breaking egg and shell egg sectors in the price–determining process. The foregoing results seem sufficiently to have confirmed the premise. The relation between these two sectors was essentially excluded from the models of earlier studies [2, 3] because of the relative insignificance of the breaking egg sector. But with the growth of egg breaking activities due to an increased aggregate as well as per capita demand for processed eggs in recent years, the interrelations between these two sectors must be taken into account in any meaningful analysis and future price–stabilizing policy decisions relating to the shell egg sector. The study also bears out the fact that the storage movement of shell eggs has lost its important role of earlier decades in the price–determining process. Apparently the growth of the breaking egg sector, in conjunction with reduced seasonality in egg production and the emphasis by modern chain stores on the sale of strictly fresh eggs, has been primarily responsible for the insignificant effect of shell egg storage activities on prices of fresh eggs.

Another important change, which has become apparent since the last half of 1971, is the impact of Marek's disease vaccine on the production process through increased rate of lay and reduced mortality rate of both layers and replacements. When the effect of the vaccine is fully realized and the process of adjustment stabilizes in the sector, a reestimation of the equations used in this study to predict production may be necessary.

The absence of appropriate and complete time–series data on variables such as culling rates and prices paid for eggs used for breaking prohibited the inclusion of such relevant variables in the models. Once a sufficiently long series is developed, the addition of these factors to the model might improve the results. It will also be desirable to reestimate the model periodically to take into account changes in the structural parameters and to maintain accuracy of prediction.

References

[1] Chicago Mercantile Exchange, Market News Department, *Chicago Mercantile Exchange Yearbook*, Chicago, Illinois, 1961–62 through 1970–71.

[2] Gerra, Martin J., *The Demand, Supply and Price Structure for Eggs*, USDA, Agricultural Marketing Service Tech. Bull. 1204, Nov. 1959.

[3] Henson, W. L., "Econometric Analysis of the Structural Relationships of Egg Production and Consumption," unpublished Ph.D. thesis, The Pennsylvania State University, 1967.

[4] U. S. Department of Agriculture, Agricultural Marketing Service, *Dairy and Poultry Market News*, *Daily Egg Report*, Chicago, Illinois.

[5] ———, Economic Research Service, *Poultry and Egg Situation*, five issues a year, Feb. 1960 through Feb. 1970.

[6] ———, *Selected Statistical Series for Poultry and Eggs through 1968*, Supplement to "Poultry and Egg Situation," ERS 232, revised January 1970, Tables 26, 44, 45, 48, 50, 62, and 66.

[7] U. S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, Jan. 1961 through Jan. 1970.

Efficiency Considerations in Butterfat Differential and Component Pricing of Milk

ROBERT E. JACOBSON AND FRANCIS E. WALKER

Producer prices for milk generally reflect only differences in butterfat content as an explicit measure of value. This paper demonstrates that such a pricing system results in inequitable payments to producers. A component pricing approach that includes component values is then suggested.

INTEREST in multiple component pricing has increased substantially in recent years. A key factor in this interest is that the feasibility, cost, and accuracy of milk protein or *SNF* testing now enable multiple component pricing to be implemented operationally with full confidence [3, pp. 14–17].[1] At the same time, consumer demand, with its emphasis on fewer calories, more protein, and less animal fats, has focused greater attention in the dairy industry on the nonfat component of milk. In fluid milk markets, for example, per capita consumption of low–fat or skim milk nearly doubled from 1965 to 1971 while per capita consumption of whole milk was dropping by 15.5 percent [4].

Class prices and producer prices for milk are generally established on a hundredweight basis with adjustments for butterfat content. The implicit assumption in this procedure is that the butterfat differential also rewards other components of milk since there is a positive average relationship between butterfat content and solids–not–fat content. The two purposes of this discussion are to evaluate the validity of the assumption that butterfat differentials compensate other components and to suggest a component pricing approach that does, in fact, efficiently value both the butterfat and solids–non–fat in milk if the butterfat differential does not adequately resolve the problem.

Inequities in Butterfat Differential Pricing

Various studies have substantiated the relationship between butterfat and solids–not–fat in producer milk. The Jack relationship [2, p. 5] typifies such studies and estimates the following function:

$$SNF = 7.07 + 0.444\,BF$$

where *SNF* and *BF* are measured in percent.

This relationship indicates that, of a given increment in total solids in milk, about 70 percent will be butterfat and 30 percent will be solids–not–fat. It is assumed that the butterfat differential rewards the total increment.

Based on the Jack study, the standard error of the regression line is 0.36.[2] Therefore, at a butterfat test of 3.5 percent, 68 percent of milk samples would reflect a *SNF* test in the range of 8.27 to 8.99 percent. This range appears to be excessive because of the fact that, for a given fat test, the butterfat differential fails to adjust producer payments for the *SNF* differences and fails to charge processors for the *SNF* differences.

Milk from an individual herd is composed of the joint products, *SNF* and butterfat, produced in a fairly precise relationship. Variations in this relationship do exist among herds within breeds and among breeds. Line M of Figure 1 represents the combinations of *BF* and *SNF* in milk which is average with respect to the *SNF–BF* ratio.[3] A producer whose herd produces relatively greater amounts of *SNF* in relation to *BF* would be represented by a point on line M_H. Similarly, line M_L represents the *BF–SNF* combinations of a herd with relatively low *SNF* content.[4]

Under the butterfat differential payment method, individual producers receive the true value of the milk they produce only if that milk has the "average" ratio of *SNF* to *BF*, i.e., only if it has the characteristics associated with line M. Line R_1 represents an iso–revenue curve faced by the producer under this pricing method.

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[1] Johnson and Christensen [3] conclude, "The extra cost to measure *SNF* and protein are reasonable. The issue of whether or not to pay by components should be decided by the economic factors involved, not the testing method." We support this conclusion.

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[2] The standard error of the regression line increases, but only slightly, as butterfat content moves away from the mean.

[3] Note that this line, if extended, would have a positive intercept. It really prescribes a rather exact relation between *BF* and *SNF* over the component range commonly found in milk.

[4] Several studies have documented the existence of these differences, e.g., [5].

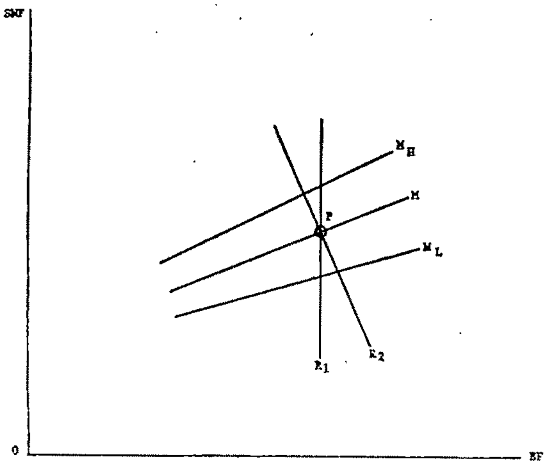

Figure 1. Output and revenue relationships of butterfat and solids-not-fat at differing price and composition value ratios

Since only butterfat differentials are recognized and rewarded, R_1 is a vertical line. Conceptually, its slope is the negative ratio of the price of butterfat (P_{BF}) to the price of *SNF* (P_{SNF}); however, since it is vertical, P_{SNF} must be zero, or more appropriately, the weight given to P_{SNF} is zero. From R_1 it is seen for a constant fat content that a producer on M_H receives nothing additional for the *SNF* he produces above the amount produced by a producer on line *M*. Similarly, the producer on M_L receives the same revenue even though he produces less *SNF*. This is the producer–producer inequity generated by the butterfat differential method of pricing.

Since P_{SNF} should receive a positive weight, the iso-revenue curve (R_2) with slope, $-P_F/P_{SNF}$, is the one which should be reflected to the producer by the pricing mechanism. For the producer on line *M*, output *P* yields the same revenue under either pricing method. But for the high *SNF* herd, an equivalent revenue is obtained with lower output of butterfat. The low *SNF* herd must produce more *BF* (more milk) to achieve the same revenue level. In summary, to the extent that milk from different herds has different ratios of *SNF* to *BF*, butterfat differential pricing produces inequities in payments to producers.

The failure of butterfat differentials to compensate *SNF* differences equitably can be evaluated by reviewing milk pricing procedures. Given a blend price and a butterfat differential, fat–skim accounting procedures establish fixed values for butterfat and skim milk. The skim milk price is then used to place a value upon *SNF*, based on an accepted average *SNF* content per 100 pounds of milk. Since any such imputation of values can be done *only* on an average *SNF* content basis, it is observed that present procedures value *SNF* higher per unit in low testing as compared to high testing milk fat dairy herds.

In addition, given the normal butterfat *SNF* relationship, the traditional butterfat differential cannot contain the respective values of butterfat and *SNF*. Within the butterfat differential, the relative value contributions of butterfat and *SNF* must appear as follows:

$$BF\text{ Value} = \frac{\Delta Q_{BF}(P_{BF})}{\Delta Q_{BF}(P_{BF}) + \Delta Q_{SNF}(P_{SNF})}.$$

The *SNF* value contribution is calculated similarly, or it might be determined by subtracting the *BF* value from the butterfat differential. The premise that the *BF* differential rewards both the *BF* and *SNF* necessarily reduces the predetermined values of *BF* and *SNF*. Loss in value is due to two components being forced into the space, i.e., butterfat differential, formerly occupied by one component. The increment of butterfat finds itself sharing the butterfat differential with the increment of *SNF*. Where the value of butterfat had been equal to the value of the butterfat differential plus value of skim milk replaced, it now becomes equal to the butterfat differential minus the *SNF* value plus value of skim milk replaced. Therefore a fundamental inconsistency exists between the premise that *BF* differential efficiently compensates the total solids increment in milk, and the ability of the preassigned values of *BF* and *SNF* (or skim milk) to reward both components.

A Suggested Pricing Plan

What is an equitable plan of paying a producer for his milk? One essential element is that both *BF* and *SNF* be explicitly recognized.

Define the third component (*W*) to be the fluid in the milk, such that

$$BF + SNF + W = 100; \tag{1}$$

that is, that these three components become the product, milk. Individual producer price per hundredweight (P_M) for milk of any test then could be determined as,

$$\begin{aligned} P_M = P_B &+ P_{BF}(F - 3.5) \\ &+ P_{SNF}(SNF - 8.63) \\ &+ P_W(W - 87.87), \end{aligned} \tag{2}$$

where P_B is the (blend) price for milk which contains 3.5 percent butterfat, 8.63 percent *SNF*, and the remainder (87.87 percent) in fluid.[5] In this formula differential payments are explicitly included for *BF*, *SNF*, and *W*. Note that with the assumption of positive prices and due to the restriction imposed by (1), all three differential effects cannot be positive (negative).

For commonly used butterfat differential pricing, the *SNF* and *W* differentials do not appear explicitly but are incorporated in the blend price (P_B) in a manner which treats all milk as if it had the same content of *SNF* and of *W*. This is reflected in the vertical iso-revenue curve in Figure 1.

Changes in P_{BF} and P_{SNF} and differences in amount of *BF* and *SNF* between herds are explicitly adjusted in determining the price (P_M) received by the individual producer. This allows the iso-revenue curve to take the form, R_2 (see Fig. 1). The presence of curve, R_2, does not argue that producers will, or even should, attempt to change the characteristics of their herd through selection as P_{BF} and P_{SNF} change. Milk processors efficiently take the milk as produced and transform it to the products with the desired *BF–SNF* content. It does show the need for considering component prices in paying the producer for what he produces.

Fluid content (W) and P_W also appear in a differential in this formula. The California plan is the only one which utilizes this fluid differential [1, pp. 22–28]. W is uniquely determined for *SNF* and *BF* by (1). P_W is determined as a residual price after the value of butterfat and *SNF* have been determined and subtracted from the total value of the milk. Basically there is no market mechanism for determining the value of the fluid in milk. From (2) and (1):

$$\begin{aligned} P_M &= P_B + P_{BF}(BF - 3.5) \\ &\quad + P_{SNF}(SNF - 8.63) \\ &\quad + P_W(100 - BF - SNF - 87.87) \\ &= P_B + (P_{BF} - P_W)(BF - 3.5) \\ &\quad + (P_{SNF} - P_W)(SNF - 8.63). \end{aligned}$$

Thus changes in P_W are incorporated with P_{BF} in determining the effect of the butterfat differential and with P_{SNF} in determining the effect of the *SNF* differential. Consequently, the iso-revenue function (R_2) reflected to the individual producer should appropriately have the slope, $-(P_{BF}-P_W)/(P_{SNF}-P_W)$, if P_W is computed. If P_W is not computed, the slope is $-P_{BF}/P_{SNF}$. In either case, the iso-revenue curve has a negative slope and rewards the producer for production of *SNF* as well as butterfat.

Conclusion

Historically, the butterfat differential has been defended and has been criticized for the way in which it rewards *SNF* variation. Clearly a substantial basis now exists for criticizing the butterfat differential for failing to distribute equitably pool monies for variations in *SNF*. Support for the move to multiple component pricing is strengthened by the increasing value of nonfat dry milk (or *SNF*) relative to butter (or butterfat) in fluid and manufactured dairy product markets. Implementation of the *BF*, *SNF* (or protein), and water pricing plan as specified would largely resolve the equity problem in producer payments. The question of what values to assign to the respective components is another matter.

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[5] The component content of the standard milk represented by the announced blend price is arbitrary. Different component contents for *BF* and *SNF* would be equally valid.

References

[1] DEMEDIROS, GEORGE, "Experiences With and Suggestions for Multiple Component Pricing plans," *Proceedings—Western Dairy Conference Symposium*, March 11–12, 1971, pp. 22–28.

[2] JACK, E. L., *et al.*, *Relationship of Solids-Not-Fat to Fat in California Milk*, California Agr. Exp. Sta. Bull. 726, Sept. 1951, p. 5.

[3] JOHNSON, FRANK R., AND LAWRENCE J. CHRISTENSEN, "Multiple Component Pricing Costs and Techniques," *Proceedings—Western Dairy Conference Symposium*, March 11–12, 1971, pp. 14–17.

[4] MATHIS, A. G., "Outlook for Dairy," paper presented at the 1972 National Agricultural Outlook Conference, ERS-USDA, Feb. 24, 1972.

[5] SMITH, A. C., *et al.*, *Some Interrelationships Between Fat, Protein, and SNF Content of Milk*, University of Connecticut Agr. Exp. Sta. Res. Rep. 9, Jan. 1966.

Milk Demand, Supply, and Price Relationships, 1950–1968*

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Demand, supply, and price relationships in the dairy sector were measured for the 1950–1968 period by two-stage least squares. Actual cow numbers adjusted more quickly to desired levels than production per cow. Own price elasticities of milk supply and consumer demands for fluid and manufactured milk were not statistically significant.

DEMAND, supply, and price relationships for milk have been estimated from multiequation models by Rojko [7] and Wilson and Thompson [21]. Rojko [7] applied ordinary least squares and limited information maximum likelihood methods to three models of the demand and price structure for dairy products. Milk production was assumed to be predetermined, and no attempt was made to measure supply relationships for producers. Wilson and Thompson [21] estimated a dairy sector model that included equations for milk supply (i.e., cow numbers, yield, and butterfat content of milk), farm–retail margins for milk, and consumer demands for fluid milk, and milkfat and solids–not–fat in manufactured dairy products. Their equations were estimated from annual data (1947–1963) by two-stage least squares and, when appropriate, ordinary least squares. Long–run price elasticities of milk supply were measured by summing the cow numbers and yield elasticities, the latter computed with respect to blend price averaged over the previous three years. Halvorson [3, 4] also estimated short–run and long–run milk supply elasticities based on a distributed lag model.

This paper attempts to measure demand, supply, and price relationships in the U. S. dairy sector for the period 1950–1968. The specified simultaneous equations model contains relationships for farm supply of milk, farm price received for milk used in manufactured dairy products, consumer demands for fluid milk products, and milkfat and solids–not–fat in manufactured dairy products, and retail prices of fluid milk, milkfat, and solids–not–fat. All equations were fitted by two–stage least squares using 1950–1968 data. The model attempts to account for possible differences in short–run and long–run demand and supply elasticities by means of the partial adjustment hypothesis [2, 6].

Model Specification

Farm–level relationships

Cow numbers (C), yield per cow (Y), and milk production (MP) equations are:

$$C = C\left(\frac{PB}{PR}, \frac{PE}{PR}, Y, \frac{W}{PR}, C[t-1], \frac{PC}{PR}\right) \tag{1}$$

$$Y = Y\left(\frac{PB}{PR}, \frac{PE}{PR}, C, BA[t-3], Y[t-1]\right) \tag{2}$$

$$MP = C \cdot Y \tag{3}$$

where:

C = average number of milk cows on farms, thousands [10, 11, 17],
Y = average production of milk per cow (yield), pounds [10, 11, 17],
MP = total milk production,
PB = average wholesale (blend) price received by farmers for milk, dollars per hundredweight [8, 10, 11],
PR = index of prices received by farmers for all commodities, 1957–1959 = 100 [8],
PE = index of the value per 100 pounds of concentrate rations fed to milk cows on farms, 1957–1959 = 100 [10, 11, 12],
W = average monthly wages paid to farm labor, dollars [8],
PC = average price of canners and cutters at Chicago, dollars per hundredweight [13, 14, 15],
BA = cows bred artificially as a percentage of all cows kept for milk [8, 10, 11].

The price of feed (PE) and farm wages (W) deflated by the index of prices received by farmers (PR) are included in the cow numbers

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equation to reflect cost of maintaining cows.[1] Farm wages are not deemed to be an important determinant of yield. Yield per cow is included in the cow numbers equation and cow numbers in the yield equation because of the interdependence of decisions relating to cow numbers and yield. The deflated price of canners and cutters (PC/PR) is used in the cow numbers relation to account for possible marketing of dairy cattle as beef during periods of favorable beef prices.

Increases in yield per cow to a great extent have been associated with improvements in breeding stock and particularly the increased use of artificial insemination. The number of cows bred artificially in a given year is likely to have its greatest (positive) effect on yield about three years later when the offspring of artificially bred cows freshen. Hence, the percentage of milk cows bred artificially, lagged three years, is used to explain yield per cow.

Since the determination of cow numbers and yield is formulated using the partial adjustment hypothesis [2, 6], one–period lagged cow numbers and yield enter the cow numbers and yield equations, respectively.[2] With this hypothesis, actual cow numbers and yield can deviate from their desired levels due to technical, economic, and other constraints not accounted for in the cow numbers and yield equations. In particular, changes in actual cow numbers and yield are proportional to the difference between actual and desired levels.[3] The factor of proportionality, or so–called adjustment coefficient, measures the rapidity with which actual levels converge to desired levels.

Farm price for milk used in fluid products (PF) is determined by the model. Farm price of manufactured milk (PM) and quantity of milk processed into manufactured dairy products (QM) are specified by:

$$(4) \qquad PM = PM(QM, MS)$$

$$(5) \qquad QM = QD + QU$$

where:

PM = average price received by farmers for manufacturing grade milk, dollars per hundredweight [8, 10, 11],

QM = quantity of milk processed into manufactured dairy products, millions of pounds [10, 11, 18],

MS = average support price for manufactured milk, dollars per hundredweight [11],

QD = quantity consumed of milk solids–not–fat in manufactured dairy products, total civilian and military disappearance, millions of pounds,[4]

QU = quantity consumed of milkfat in manufactured dairy products, total civilian and military disappearance, millions of pounds.[5]

Since the farm price of manufactured milk can reflect relative changes in raw milk supply and consumer demand for manufactured dairy products, the coefficient of QM could be positive or negative. However, farm manufactured price is expected to be positively related to the manufactured support price. Equation (5) states the equilibrium condition that quantity of milk processed into manufactured dairy products (QM) equals the quantity consumed ($QD+QU$).

The deflated blend price received by farmers is defined by:

$$(6) \qquad \frac{PB}{PR} = \frac{QL \cdot PF + QM \cdot PM}{QL + QM} \cdot \frac{1}{PR} .$$

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[1] It is recognized that farm wages may be an important determinant of the number and size of farms and to a lesser extent the number of cows. However, the model does not attempt to explain number and size of dairy farms. Moreover, the price of labor is an important component of the costs of producing milk, and increases in farm wages may induce farmers to reduce the number of cows in an effort to lower production costs.

[2] To avoid high multicollinearity, lagged yield and lagged cow numbers were excluded from the cow numbers and yield equations, respectivelv.

[3] More specifically, $y_t^* = x_t'\beta + u_{t1}$ and $y_t - y_{t-1} = \gamma(y_t^* - y_{t-1}) + u_{t2}$, where y_t^* is the desired level, y_t is the actual level, x_t is a vector of explanatory variables, β is a vector of unknown parameters, γ is the adjustment coefficient ($0 < \gamma \leq 1$), and u_{t1} and u_{t2} are stochastic disturbance terms. After substitution, $y_t = x_t'\beta\gamma + (1-\gamma)y_{t-1} + v_t$, where $v_t = \gamma u_{t1} + u_{t2}$. If $E(u_t u_s) = 0$, $(t \neq s)$, then v_t and y_{t-1} are uncorrelated.

[4] Data on this variable were derived as follows: QD = total disappearance of solids-not-fat [9, 10, 11], minus disappearance of solids-not-fat in fluid milk and cream consumed off farms [9, 11] minus estimated disappearance of solids–not–fat in fluid milk and cream consumed on farms. The last term was obtained by multiplying the percentage of solids–not–fat in fluid milk and cream consumed off farms by the quantity of fluid milk and cream consumed on farms.

[5] Data on this variable were derived as follows: QU = total disappearance of milkfat [9, 10, 11] minus disappearance of milkfat in fluid milk and cream consumed off farms [9, 11] minus estimated disappearance of milkfat in fluid milk and cream consumed on farms. The last term was obtained by multiplying the percentage of milkfat in fluid milk and cream consumed off farms by the quantity of fluid milk and cream consumed on farms.

Retail–level relationships

Consumer demand equations for fluid milk, and milkfat and solids–not–fat in manufactured dairy products are, respectively:[6]

$$(7)\quad QL/N = D_1(PL/CP,\ IB/CP,\ [QL/N]_{t-1},\ T)$$

$$(8)\quad QU/N = D_2(PU/CP,\ PD/CP,\ PO/CP,\ [QU/N]_{t-1},\ T)$$

$$(9)\quad QD/N = D_3(PD/CP,\ PU/CP,\ [QD/N]_{t-1}, T)$$

where:

QL = quantity consumed of milk and cream, total civilian and military disappearance, millions of pounds [9, 10, 11],

PL = average retail price of fluid milk, cents per pound [9, 10, 11],

PU = average retail price of milkfat, cents per pound,[7]

PD = average retail price of solids–not–fat in manufactured dairy products, cents per pound,[8]

IB = index of retail prices of beverages, 1957–1959 = 100 [16],

PO = average retail price of colored oleomargarine, cents per pound [9, 10, 11],

CP = consumer price index, all commodities, 1957–1959 = 100 [16],

N = population, millions [19],

T = time (coded: 1, 2, · · · , 19).

Per capita consumption of fluid milk (QL/N) depends on the real price of fluid milk (PL/CP), the real price of substitute beverages (IB/CP), lagged per capita consumption $(QL/N)_{t-1}$, and time (T). In the solids–not–fat and milkfat demand equations, per capita consumption depends on the deflated retail prices of solids–not–fat and milkfat, lagged per capita consumption and time. Consumption is expressed in per capita terms and prices in real terms to account respectively for changes in population and the general price level. Time is included in all three demand equations as a proxy for changes in consumer tastes and preferences.[9]

The partial adjustment hypothesis was used in the consumer demand equations to account for consumer delays in adjusting actual consumption to desired consumption. Such delays often result from habit persistence, imperfect market information, and other factors. Use of the partial adjustment hypothesis accounts for the inclusion of lagged per capita consumption in the demand equations.

Actual retail prices are determined by the following farm–retail margin equation:

$$(10)\quad PL = PL(PF,\ IC)$$

$$(11)\quad PU = PU(PM,\ IC)$$

$$(12)\quad PD = PD(PM,\ IC)$$

where:

PF = average price received by farmers for fluid grade milk, dollars per hundredweight [8, 10, 11],

IC = index of compensation per man hour in manufacturing industries [20].

The index of compensation is included to reflect costs of processing and distributing dairy products. To ensure that the model defines an equilibrium system, the following production–consumption condition is required:[10]

$$(13)\quad \mathrm{MP} = \mathrm{QL} + \mathrm{QM}.$$

Method of Estimation

The above model is complete and contains 18 endogenous and 16 exogenous variables (Table

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[6] Deflated retail prices are defined in terms of actual retail prices as follows: $PL/CP = PL(1/CP)$, $PU/CP = PU(1/CP)$, $PD/CP = PD(1/CP)$.

[7] Data on this variable were derived as follows: $PU = (0.803 \cdot$ retail price of butter $[9, 10, 11] + 0.323 \cdot$ retail price of cheese $[9, 10, 11]) \div 1.126$, where all prices are expressed in dollars per pound. The coefficient of each price represents the proportion of milkfat in one pound of that product. Lack of a comparable retail price series for ice cream during the 1950–1968 period prevented its inclusion in the formula. The author recognizes that this formula only approximates the retail price of milkfat.

[8] Data on this variable were derived as follows: $PD = (0.308 \cdot$ retail price of cheese $[9, 10, 11] + 0.962 \cdot$ wholesale price of nonfat dry milk $[9, 10, 11] + 0.180 \cdot$ retail price of evaporated milk $[9, 10, 11]) \div 1.450$, where all prices are expressed in dollars per pound. The coefficient of each price represents the proportion of milk solids–not–fat in one pound of that product. The author recognizes that this formula only approximates the retail price of solids–not–fat.

[9] Income was excluded from the demand equations because it was felt that meaningful estimates of income effects could not be obtained from time series data. Often, income effects derived from time series data are inaccurate because the income effect becomes confounded with effects of other factors that vary over time such as tastes and preferences. If time and income are included in the same equation, due to high multicollinearity it is usually not possible to estimate accurately their separate effects on consumption.

[10] QL and QM are defined in terms of per capita consumption as follows: $QL = (QL/N)N$, $QM = (QD/N + QU/N)N$.

Table 1. Endogenous and exogenous variables

Endogenous		Exogenous	
QL/N	PD/CP	IB/CP	$QD/N(t-1)$
QL	PD	$QL/N(t-1)$	MS
PL/CP	PM	T	PE/PR
PL	QM	IC	W/PR
PF	PB/PR	N	$C(t-1)$
QU/N	MP	CP	PC/PR
PU/CP	C	PO/CP	$BA(t-3)$
PU	Y	$QU/N(t-1)$	$Y(t-1)$
QD/N	$QD+QU$		

1). Application of two–stage least squares to the stochastic equations of the model presents a problem because a closed reduced form cannot be obtained. This occurs because the structural equations contain regressors, e.g., blend price, that are nonlinear functions of certain endogenous variables. However, Kelejian [5] has shown that consistent two–stage least squares estimates can be derived by approximating the reduced form equations by a polynomial in all exogenous variables. Due to the limited number of observations (19), all reduced form equations were estimated using only linear terms (first degree polynomial) in the exogenous variables. All functional relationships were specified to be linear in the variables since this form yields a more direct estimate of the adjustment coefficient.[11]

Results

Table 2 contains the coefficients, *t*-ratios, and elasticities or flexibilities for the nine stochastic equations of the model. Equations (3), (5), (6), and (13) were not estimated because they were definitions. Since all coefficients were estimated by two–stage least squares, the *t*-test is only asymptotically valid. Coefficients of multiple determination (R^2) are not reported. For equations fitted by a simultaneous equations method, R^2 can be negative and generally has a range of $[-\infty, 1]$ instead of the $[0, 1]$ range that obtains with single equation methods [1].

Equation (1) indicates that cow numbers are inversely related to yield and the price of canners and cutters. None of the remaining coefficients of this equation are significantly different from zero at the 5 percent level. Elasticities indicate that cow numbers are most responsive to yield followed by lagged cow numbers and canner–cutter price. The cow numbers adjustment coefficient 0.823 (estimated by one minus the coefficient of lagged cow numbers) implies that actual cow numbers adjust quite rapidly to desired cow numbers—a value of one indicates complete adjustment in one year.

Equation (2) indicates that yield per cow is directly related to percentage of cows bred artificially and to lagged yield. Remaining coefficients are not statistically different from zero at the 5 percent level. The 0.326 adjustment coefficient for yield suggests a relatively slow rate of adjustment between actual and desired yield. Since the yield adjustment coefficient is less than half the cow numbers adjustment coefficient, actual cow numbers adjust more quickly to desired levels than yield per cow. This result is not too surprising. During the 1950–1968 period cow numbers declined steadily as less efficient producers decreased in number and yield increased rather slowly due to the lags between yield response and improvements in breeding and feeding

Table 2. Coefficients, *t*-ratios, and elasticities or flexibilities for dairy sector model, 1958–1968

Dependent variable, equation number	Explanatory variable	Coefficient[a]	*t*-ratio	Elasticity or flexibility[b]
C, (1)	PB/PR	−101.716	0.275	−0.023
	PE/PR	−2.627	0.145	−0.015
	Y	−1.950**	5.419	−0.741
	W/PR	0.721	0.109	0.007
	$C(t-1)$	0.177	1.441	0.182
	PC/PR	−112.064*	2.667	−0.084
Y, (2)	PB/PR	75.652	0.901	0.046
	PE/PR	0.574	0.128	0.008
	C	−0.069	1.114	−0.183
	$BA(t-3)$	17.766**	3.918	0.066
	$Y(t-1)$	0.674**	4.572	0.654
PM, (4)	QM	−0.00001	1.055	−0.184
	MS	0.909**	9.024	0.887
QL/N, (7)	PL/CP	−2.674	0.563	−0.105
	IB/CP	0.103	0.907	0.035
	$QL/N(t-1)$	1.000**	6.640	1.001
	T	−0.397	1.199	−0.014
QU/N, (8)	PU/CP	−0.347	0.779	−0.198
	PD/CP	−0.616	0.663	−0.126
	PO/CP	0.094	1.204	0.213
	$QU/N(t-1)$	0.301	1.062	0.307
	T	−0.071	1.363	−0.056
QD/N, (9)	PD/CP	−1.079	1.151	−0.196
	PU/CP	−0.175	0.403	−0.089
	$QD/N(t-1)$	0.611**	3.367	0.606
	T	0.062	1.163	0.043
PL, (10)	PF	0.843**	4.914	0.357
	IC	0.047**	12.230	0.428
PU, (11)	PM	1.069**	8.871	0.500
	IC	0.018**	6.640	0.257
PD, (12)	PM	0.593**	7.670	0.769
	IC	0.172**	9.530	0.657

[a] Estimated by two–stage least squares.
[b] Evaluated at the means.
* Significantly different from zero at the 5 percent level.
** Significantly different from zero at the 1 percent evel.

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[11] In the linear form the adjustment coefficient is measured by one minus the coefficient of the lagged regressand.

programs. The significance of the coefficient of cows bred artificially, lagged three years, illustrates the importance of one such lag. Also, the cow numbers–yield elasticity, −0.741, and the yield–cow numbers elasticity, −0.183, indicate that cow numbers are more responsive to changes in yield than yield is to changes in cow numbers.

Insignificance of the blend price coefficients in the cow numbers and yield equations suggests that the supply of milk is not responsive to current blend price in the short run. A long-run price elasticity of milk supply would not be too meaningful in the present case because it depends on the blend price coefficients which were not significant.

Equation (4) indicates that the farm price of manufactured milk is not significantly related to quantity of milk used in manufactured products but is directly related to the manufactured support price.

In the fluid milk demand equation (7) the coefficients of fluid milk price, beverage price, and time are not significantly different from zero at the 5 percent level. Own fluid price elasticities estimated by Wilson and Thompson [21] and Rojko [7] were also insignificant (based on the t-test). The computed zero adjustment coefficient for milk is quite improbable since it implies an infinite rate of adjustment between actual and desired milk consumption.

Own price coefficients were also insignificant in the milkfat and solids–not–fat demand equations. Similar results were obtained by Wilson and Thompson [21]. Compared to the own price elasticities estimated by Wilson and Thompson [21], the (short–run) milkfat elasticity obtained here is smaller in absolute value, and the solids–not–fat elasticity is the same: −0.19 vs. −0.43 for milkfat and −0.19 for solids–not–fat. Long–run price elasticities for milkfat and solids–not–fat were not computed because of the insignificance of the short–run price coefficients. Of the remaining coefficients in the milkfat and solids–not–fat demand equations, only the coefficient of lagged per capita solids–not–fat consumption is statistically significant and implies an adjustment coefficient of 0.389.

Retail price equations (10), (11), and (12) show that retail milk prices are directly related to the corresponding farm price and the index of compensation per man hour, the latter being a proxy for the costs of processing and distribution. Estimated retail–farm price flexibilities for fluid milk, milk-fat, and solids–not–fat are 0.357, 0.5, and 0.769, respectively. These flexibilities suggest that retail prices of milkfat and solids–not–fat are more responsive to farm manufactured price than retail fluid price is to farm fluid price.

Concluding Remarks

The purpose of this paper was to measure aggregate demand, supply, and price relationships for the U. S. dairy sector during the 1950–1968 period. Admittedly the structural model developed here represents one of many possible formulations that can be used to measure these relationships. Perhaps the most dominant result obtained with the present model is the insignificance of the own price elasticities of milk supply and of demand for fluid milk, and milk-fat and solids–not–fat in manufactured dairy products. This result may have been caused by incomplete specification of the supply and demand equations and/or deficiencies in the data. However, these elasticities were found to be insignificant in other studies based on national data. Regulation of minimum farm prices for fluid and manufactured milk by federal or state market orders complicates the estimation of milk price elasticities. Most dairy sector models, including the present one, implicitly assume free market conditions. Prices in a free market are determined by demand and supply conditions whereas regulated prices are determined by administrative decisions. Consequently the aggregate demand and supply elasticities reported here may be distorted by the discrepancy between model assumptions and actual market conditions. Alternatively, the insignificance of these elasticities could be interpreted as further evidence of the unresponsiveness of milk supply and demand to own price changes.

Both interpretations offer little comfort since there still remains some doubt about the nature of supply response to current blend price and purchase response to retail prices. Some researchers maintain that more decisive information about milk price elasticities can be obtained from less aggregative models and data sources. Less aggregative approaches have their share of difficulties. For example, estimation of own price elasticities of demand from disaggregated cross section or time series data is often hampered by the limited variation and/or errors of measurement in retail prices. Despite such difficulties there has been an increase in the use of regional, state, and local data to estimate price elasticities of demand for fluid milk and manufactured dairy products. Continued efforts in this direction coupled with more reliable data will hopefully provide further information about supply and demand elasticities for milk and dairy products.

References

[1] BASMANN, R. L., "Letter to the Editor," *Econometrica* 30:824–826, Oct. 1962.
[2] DHRYMES, PHOEBUS J., *Distributed Lags: Problems of Estimation and Formulation*, San Francisco, Holden-Day, Inc., 1971.
[3] HALVORSON, H. W., "The Supply Elasticity for Milk in the Short Run," *J. Farm Econ.* 39:1186–1196, Dec. 1965.
[4] ———, "Response of Milk Production to Price," *J. Farm Econ.* 40:1101–1113, Dec. 1958.
[5] KELEJIAN, HARRY H., "Two-Stage Least Squares and Economic Systems Linear in Parameters but Nonlinear in the Endogenous Variables," *J. Am. Stat. Assoc.* 66:373–374, June 1971.
[6] NERLOVE, MARC, *Distributed Lags and Demand Analysis for Agricultural and Other Commodities*, USDA Agr. Hdbk. 141, June 1958.
[7] ROJKO, ANTHONY S., *The Demand and Price Structure for Dairy Products*, USDA Tech. Bul. 1168, 1957.
[8] U. S. Department of Agriculture, *Agricultural Statistics*, 1967 and 1970.
[9] ———, *Dairy Situation*, ERS, 1968–70 Series.
[10] ———, *Dairy Statistics through 1960*, Stat. Bul. 303, Feb. 1962.
[11] ———, *Dairy Statistics, 1960–67*, Stat. Bul. 430, July 1968.
[12] ———, *Feed Situation*, May 1970.
[13] ———, *Livestock and Meat Statistics, 1962*, Stat. Bul. 333, Aug. 1964.
[14] ———, *Livestock and Meat Statistics, 1963*, Sup. to Stat. Bul. 333, Aug. 1964.
[15] ———, *Livestock and Meat Statistics, 1968*, Sup. to Stat. Bul. 333, July 1969.
[16] ———, *National Food Situation*, Feb. 1969.
[17] ———, *Milk Production and Dairy Products, Annual Statistical Summary, 1969*, SRS, Feb. 1970.
[18] ———, *Milk Production, Disposition and Income, 1967–68*, April 1969.
[19] U. S. Department of Commerce, Office of Bus. Econ., *Survey of Current Business*, 1950–1969 Series.
[20] U. S. Department of Labor, Bur. of Lab. Stat., *Handbook of Labor Statistics, 1970*, Bulletin 1666, 1970.
[21] WILSON, ROBERT, R., AND RUSSELL G. THOMPSON, "Demand, Supply, and Price Relationships for the Dairy Sector," *J. Farm Econ.* 49:360–71, May 1967.

Distributed Lag Estimation of Harmonic Motion in the Hog Market*

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The harmonic motion model as explanation of some markets' behavior is an alternative to the cobweb model. A distributed lag technique for estimating harmonic motion is presented. Results are consistent with the four-year period observed in the hog cycle; an inference about farmers' expectations can be made from the results.

THE validity of the cobweb theorem as an appropriate model of the hog cycle has been challenged numerous times. Arnold Larson [4, 5] has proposed a harmonic model to explain the four-year cycle in hogs. James Lorie [6] described a similar model of the cattle cycle. With the exception of one harmonic study of hog production [1], it appears that very little empirical research has tested the harmonic hypothesis. Therefore this paper presents a possible estimation technique.

One way to view the hog market is to formulate a discrete model of production similar to that of Metzler [7]. It could be postulated that marketings, q_t, is a linear function of marketings in the previous year, q_{t-1}, plus an adjustment for expectations based on the difference in marketings in the previous two years, plus unexpected changes, v_t.

$$\begin{aligned} q_t &= \beta q_{t-1} + \gamma(\beta q_{t-1} - \beta q_{t-2}) + v_t \\ &= (1+\gamma)\beta q_{t-1} - \gamma\beta q_{t-2} + v_t. \end{aligned} \tag{1}$$

Here β, and γ, the coefficient of expectation, are constants. Furthermore, from the law of demand, price should behave harmonically also but should move inversely to marketings.

A second order difference equation of the form,

$$a z_t + b z_{t-1} + c z_{t-2} = m \tag{2}$$

where a, b, c, and m are constants, has as its complementary solution, z_c, the equation:

$$z_c = (c)^{\frac{1}{2}t}[A \cos(xt) + B \sin(xt)] \tag{3}$$

if $b^2 < 4ac$. The angle x is determined from the formula $x = \cos^{-1}[(-b/2)/(c^{\frac{1}{2}})]$. The particular solution of (2), z_p, is a function of trend. The general solution is then $z_t = z_p + z_c$. (See [2, pp. 532–539].)

Equation (2) can be estimated by the distributed lag equation:

$$z_t = a_1 - b z_{t-1} - c z_{t-2} + a_2 f(t) \tag{4}$$

where b and c are estimates of $-(1+\gamma)\beta$ and $\gamma\beta$, respectively. The trend term $f(t)$ can be used as an estimate of the particular solution.

While other techniques exist to determine harmonic movement in time series, including spectral analysis and those in [1], use of an *OLS* distributed lag model allows the value of the coefficients given in equation (1) to be determined. It is also a convenient method (subject to [3]; see below) because little additional data are needed. Furthermore, it allows the x values to be determined, while in the regressions of z_t on values of cos (xt) and sin (xt), as in [1], x must be specified.

Annual data on the hog–corn ratio (as a measure of value)[1] and for commercially slaughtered hogs (as a measure of marketings) were used in the regressions below. Data are from [8][2] and cover the years 1952–68. Deviations from the 1952 value of both the hog–corn ratio and marketing series were used. It can be demonstrated that if the 1952 value is the "normal" value of the series, then a_1 will be $(-a_2)$ times the mean of the trend values.[3] Time is measured in years, i.e., $t_1 = 1952$; $t_{17} = 1968$. Alternative functions of trend, $f(t)$, were tested—specifically, $1/t$, t, ln (t), exp (t); in each case the natural logarithm gave the highest R^2.

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[1] The hog–corn ratio is defined in [8] as the "number of bushels required to buy 100 pounds of live hogs at local markets, based on the average prices received by farmers for crop and corn."

[2] Table 477, 1969, and Table 489, 1959, for hog–corn ratio data for 1950–68; Table 473, 1969, and Table 481, 1965, for commercially slaughtered hog data for 1950–68.

[3] A mathematical statement of the preceding is available from the author upon request.

The regressions for marketings, q_t, and for the hog–corn ratio, p_t, are (with standard deviations in parentheses),

$$
(5)\qquad \begin{aligned} q_t = &- \underset{(3023000.)}{14980000.} + \underset{(0.1710)}{0.2656q_{t-1}} \\ &- \underset{(0.1710)}{0.7493q_{t-2}} + \underset{(398800.)}{1976000 \ln(t)} \end{aligned}
$$

$$
\bar{R}^2 = 0.7062 \qquad \text{SEE} = 3131.8 \qquad F = 13.817
$$

$$
(6)\qquad \begin{aligned} p_t = &- \underset{(1628.)}{7555.0} - \underset{(0.1941)}{0.0397p_{t-1}} - \underset{(0.1916)}{0.7088p_{t-2}} \\ &+ \underset{(214.9)}{997.6 \ln(t)} \end{aligned}
$$

$$
\bar{R}^2 = 0.6196 \qquad \text{SEE} = 1.5152 \qquad F = 9.6860.
$$

In equations (5) and (6) the c value is not significantly different from one at the 5 percent level of significance; in both cases b is not significantly different from zero at the 5 percent level. Thus the hypothesis that x equals ninety degrees cannot be rejected; equation (3) should trace out a stable pattern of oscillations (as $c=1$, statistically). In both cases a_1 is not different from $(-a_1)$ times the mean of the log trend values. Both equations (5) and (6) fail to reject the null hypothesis that there is no serial correlation among the residuals in the distributed lag regressions. (Approximate values for h in (5) and (6) are 0.287 and −0.287, respectively;[4] see [3, p. 419].)

The regression results as used in equation (3) trace out the four-year period that has been observed in the hog cycle [4]. If marketings are a constant proportion of the number of hogs on farms the previous year (used as a measure of production; see [6]), then it is also assumed that production behaved harmonically. In this case regression results would occur, giving time paths in hog production, prices, and marketings similar to Lorie's hypothesized cattle paths [6, pp. 54–57]. An insignificant correlation coefficient of −0.1621 was estimated between price and quantity. This result does not support the hypothesis that the number of slaughtered hogs is inversely related to the hog–corn ratio.

As $(1+\gamma)\beta=0$ and $\gamma\beta=1$ (statistically), it follows that γ and β may not differ from −1. That is, if marketings are high one period, farmers expect them to be low the following period.[5]

While the insignificant b value may be indicative that the z_{t-1} value in both cases is not very informative, it does help establish the angle value in (3). A regression of the form,

$$
z_t = a + bz_{t-2},
$$

assumes the angle value to be ninety degrees.

It has been shown that a distributed lag equation can help a researcher determine whether an economic time series behaves harmonically. Use of monthly data, as in [1], may help the researcher determine the "true" lags involved. See [1] for techniques (not involving distributed lags) to determine whether changes in phasing or amplitude have occurred in the time paths over the period studied.

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[4] The Durbin-Watson d statistics (used in calculating the h statistics) are 1.897 and 2.11, respectively.

[5] One criticism of the cobweb model is that it assumes farmers expect current prices to remain unchanged into the next period (see [4]).

References

[1] Abel, Martin E., "Harmonic Analysis of Seasonal Variation with an Application to Hog Production," *J. Am. Stat. Assoc.* 57:655–667, Sept. 1962.

[2] Chiang, Alpha, *Fundamental Methods of Mathematical Economics*, New York, McGraw-Hill, 1967, Chapter 17.

[3] Durbin, J., "Testing for Serial Correlation in Least-Squares Regression when some of the Regressors are Lagged Dependent Variables," *Econometrica* 38:410–421, May 1970.

[4] Larson, Arnold B., "The Hog Cycle and Harmonic Motion," *J. Farm Econ.* 46:375–86, May 1964.

[5] ———, "The Quiddity of the Cobweb Theorem," Stanford University, *Food Research Institute Studies* 7: 165–175, 1967.

[6] Lorie, James, *Causes of Annual Fluctuations in the Production of Livestock and Livestock Products*, Chicago, University of Chicago Press, 1947, Chapter 3.

[7] Metzler, Lloyd, "The Nature and Stability of Inventory Cycles," *Rev. Economics & Stat.* 23:113–129, Aug. 1941.

[8] U. S. Department of Agriculture, *Agricultural Statistics* Washington, D. C., U. S. Government Printing Office.

Farm Commodity Price Stabilization through Futures Markets*

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A proposal to stabilize farm prices through government operations in futures markets was examined using soybeans for 1953–1967. The example showed that soybean prices would not have been stabilized. Operation of the proposal might also have modified buying and selling behavior and cash-futures price relations.

PRICE stabilization has long been an objective for American agriculture. Government farm programs involving price support and storage have been used to help attain this objective, along with other goals such as raising farm income and providing reserve stocks to meet production and demand uncertainties at home and abroad.

H. S. Houthakker has suggested a program to stabilize commodity prices through government operations in key futures markets [4]. He maintains that wide price fluctuations occur because "there are not enough traders who are willing or able to take a longer view" [4, p. 51] and argues that "the key to successful stabilization is in the correct distribution of supplies over time through storage at times of surplus and release from storage at times of scarcity" [4, pp. 52–53]. In Houthakker's view these stocks should be held by private individuals, and, in fact, the government can assist private stockholders by taking appropriate action in the futures market. Houthakker further argues that this would withdraw the government from direct involvement in commodity storage and marketing. Moreover, storage by private firms would be socially desirable because they derive greater convenience yield[1] from the stocks than the government.

This paper reports the results of a study which examined Houthakker's proposal using historical data on soybeans. The existence of an active futures market and relative freedom from government controls in production and marketing were important considerations in the selection of this commodity.

Houthakker's Proposal

Conceptually, the proposal implies a simplified cobweb type interaction between aggregate supply and demand over time [2, 7]. Current price is influenced by the size of the current crop, which is in turn a consequence of farmers' reactions to prices in previous years. Houthakker suggests that spot prices be stabilized around their three year moving average:

> Government intervention in commodity markets should therefore be designed to prevent, or at least mitigate, unduly large price movements while leaving scope both for the day to day price changes that are essential to the marketing process and for the long run price trends that reflect basic developments in production and consumption. The first of these conditions can be achieved by limiting official intervention as much as possible to operations in the futures market on a stand-by basis and the second by providing for gradual adjustment in the rules governing intervention. [4, p. 55]

A Commodity Stabilization Agency (*CSA*) would be established to operate in futures markets under the following rules:

(1) Prices would be stabilized around a three-year moving average of commodity spot prices called the Indicator Price (*IP*).

(2) Above and below the *IP* are Agency Ceiling and Floor prices—*CP* and *FP* respectively. These two limits would be a certain percentage above and below the *IP*.

(3) Between the *IP* and *CP* would be the Agency Selling Price, *SP*; between the *IP* and *FP* would lie the Agency Buying Price, *BP*. Spot prices could fluctuate freely between *BP* and *SP*. Once spot prices moved outside this range, the *CSA* would operate in the futures market to affect demand for the commodity through time, thus bringing the spot price back between *BP* and *SP*.

(4) The *CSA* would trade only in contracts six to nine months from maturity.

The rationale underlying the scheme is as follows. When $P<BP$, the *CSA* would buy

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[1] Convenience yield is a property similar to that of liquidity which money possesses. Inventories enable the holder to draw on stocks readily as they are needed for such uses as processing or merchandising.

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distant futures contracts. Private traders could then store the commodity and sell contracts at a distant point in time as a hedge. This would result in rising spot prices and redistribution of stocks through time. When $P>SP$, the *CSA* would sell distant contracts; private traders would close out hedges and place stocks on the spot market, thus reallocating stock utilization through time.

A Specific Model

To evaluate the proposal in terms of the soybean example, the following assumptions were made:

(1) Alternate *BP* and *SP* levels of ±15 percent and ±20 percent of *IP* were used.

(2) Alternate aggregate farm level demand elasticities of -1.0 and -0.5 were assumed. In general, the more elastic the demand function at a given point, the larger the quantity of the commodity that would have to be stored or released from storage to bring a given rise or fall in price.

(3) Long-run supply response was not affected by operation of the scheme; short-run supply (within a year) was predetermined; i.e., supply elasticity was zero. These assumptions permit examination of shifts of supply through time purely as a result of stock accumulation or depletion. The only effect of the proposal carried over from one month to the next was the change in stock levels.

(4) Existing stock demand was not affected by operation of the proposal; thus stockholders did not adjust stockholding positions in anticipation of the operation of the proposal.

(5) Soybeans stored as a result of *CSA* action returned to the market seven months later. This simplification of Houthakker's proposal that hedging occur only six to nine months from maturity did not greatly change the results. With *CSA* operations in one direction for several consecutive months, it made little difference if each month's contracts expired in two to three separate months or all in one month.

(6) Intertemporal prices were unrelated, so the redistribution of stocks through time was the sole concern. Associated with this was an assumption that the supply of storage function is infinitely elastic, so storage space was always forthcoming to hold whatever stocks needed to be held.

It was implicitly assumed that the operation was technically feasible. Also, the assumptions outlined were believed to be favorable to successful operation of the scheme, including the assumption that implementation of the proposal would not alter the behavior of market participants nor basic supply and demand response relationships. Assumption 6 was an attempt to determine the minimum amount of contract trading necessary to achieve Houthakker's stock redistribution objective, given the assumptions of the model.

The Data and Calculation Procedure

Data used were average monthly farm level prices and average monthly reported sum of exports plus crushings of soybeans for the period 1953–1967. *CSA* trading policies would be established at the beginning of each month and would remain constant for one month. Market traders would know trading policies in advance, thus minimizing uncertainty about *CSA* actions.

The *IP* was calculated as a three year moving average of 36 monthly prices, held at that level for the following 12 months, then recalculated every 12 months thereafter. Monthly prices were then examined to determine what *CSA* action, if any, was called for. Where price was below *BP* (above *SP*), the percentage by which price needed to be raised (lowered) to reach *BP* (*SP*) was determined. Through use of the formula for demand elasticity, this yielded monthly quantities that needed to be redistributed through time by *CSA* action. The average price prevailing in any month thus determined *CSA* actions for the following month.

When $P<BP$ occurred, *CSA* action resulted in a given quantity of soybeans reaching the spot market seven months later. When this month was reached later in the calculations, the depressing effect on price was calculated through the formula for elasticity of demand. Adjusted prices were then inspected to determine if *CSA* action was necessary. This procedure is the equivalent of "rolling-forward" contracts if further *CSA* action is involved. The procedure for $P>SP$ is analogous to that outlined above, except that operations and outcomes are opposite to those for $P<BP$.

At the end of each marketing year *IP* was recomputed. For the year beginning October 1953, *IP* was based on the 36 months from September 1950 to September 1953. The *IP* for the year beginning October 1954 used

September 1951 to September 1953 monthly prices plus prices resulting from operation of the scheme for October 1953 to September 1954. Thus the effects of the scheme on prices and quantities were carried forward.

The Results

Effects on prices

By assumption the proposal stabilized monthly prices. Stabilization at *IP* ±15 percent required substantial involvement in futures trading and caused a more pronounced time trend in annual average prices received by farmers (Fig. 1). This resulted because falling prices (1953–1959) were accentuated by shifting stocks forward on a falling market. During the 1960–1964 period $P > SP$ depleted stocks thus accelerating the rise in prices in subsequent periods. Stabilizing at *IP* ±20 percent resulted in less intervention but had a similar influence.

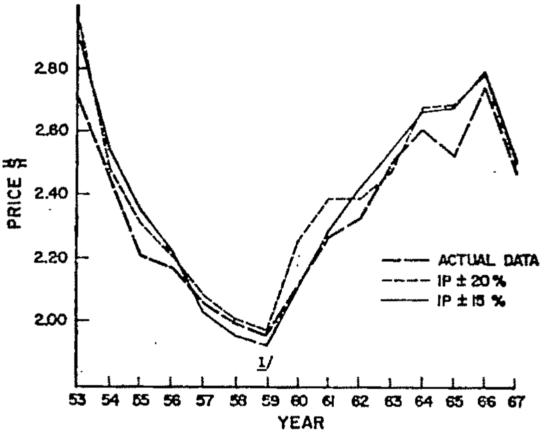

Figure 1. Soybean price, actual and indicated under alternative assumptions

[1] For IP ± 15% the estimated large carryover of 51.8 million bushels in August 1958 indicated a negative price. The carryover was then dropped and the calculations started anew.

The implication of the above conclusion is that a three-year moving average is backward looking and fails to predict correctly the price trends from year to year. Stocks were not hedged far enough in advance to be carried over into a time period when the trend in prices was reversed.

Effects on stocks

The proposal constrains the spot market to put pressure for adjustment on stocks rather than prices. Changes in annual stock levels are shown in Table 1. A fall in the absolute value of the elasticity or an increase in the range of permitted price fluctuations reduced the amount of stock redistribution through time.

Table 1. Stock accumulation and depletion under the alternative assumptions used, 1953–1967

Year	IP ± 20%		IP ± 15%	
	E = −1.0	E = −0.5	E = −1.0	E = −0.5
	million bushels			
1953	−4.14	−2.07	−7.51	−3.76
1954	2.09	1.05	4.49	2.25
1955	9.73	4.87	34.57	17.29
1956	0.75	0.38	35.35	17.68
1957			66.53	33.27
1958				
1959			16.96	8.48
1960	−24.25	−12.13	−42.74	−21.37
1961	−3.23	−1.62	−55.19	−27.60
1962			−23.53	−11.77
1963			−10.63	−5.32
1964			−2.92	−1.46
1965	−11.94	−5.97	−17.67	−8.84
1966			−1.08	−0.54
1967				

Effects on futures trading

Table 2 indicates the number of contracts traded under alternative assumptions. Over the period 1954–1958 with $P < BP$ the *CSA* would have bought contracts. Private traders would have held stocks and hedged by selling contracts to the *CSA*. Seven months later these stocks would have returned to the market necessitating purchase of more target contracts until $P \geq BP$ again. This is equivalent to "rolling over" of contracts held by private traders.

Table 2. Number of contracts traded under alternative assumptions 1953–1967

Year	IP ± 20%		IP ± 15%	
	E = −1.0	E = −0.5	E = −1.0	E = −0.5
	numbers of contracts			
1953	828	414	1502	752
1954	418	210	898	450
1955	1946	974	6914	3458
1956	150	76	7070	3536
1957			13306	6654
1958				
1959			3392	1696
1960	4850	2426	8548	4274
1961	646	324	11038	5520
1962			4706	2354
1963			2126	1064
1964			584	292
1965	2388	1194	3534	1768
1966			216	108
1967				

When prices were rising ($P>SP$) over the period 1960–1966, the *CSA* would continually have sold contracts. After the first seven months the *CSA* would have been forced to sell short. Stocks would have to have been held for delivery in the event the *CSA* could not buy back before maturity. The size of stocks would have depended on elasticity and stability assumptions and would have ranged from 19 to 155 million bushels.

Evaluation of the Proposal

Several aspects of the model should be recognized in evaluating the proposal. The analysis is comparative statics in the sense of comparing final equilibria under alternative restrictive assumptions. The adjustment path from one equilibrium position to another is not specified. Assumptions also need to be carefully evaluated as to their plausibility.

It was assumed that the proposal would not have altered long-run supply response from that which occurred. If, over the 1953–1959 period, the proposal raised average prices, production may have been stimulated, necessitating larger volumes of futures trading and stock accumulation than indicated in this study. If prices were lowered in the 1963–1966 period, production might have been restrained thus increasing the volume of short selling of futures contracts and the amount of stock depletion. Since the proposal did not stabilize annual prices, the argument that more stable prices would have altered supply response cannot be made. Even if annual prices had been stabilized, it is not clear how supply would have responded.

Assumption (4), that existing stock demand is not affected by operation of the proposal, may not be justified. Given confidence that the *CSA* could achieve $P \geq BP$, private traders may take up stocks when $P<BP$ occurred without any *CSA* futures trading being necessary. This would reduce the amount of futures trading by the *CSA*. The *CSA* would have to operate on a trial and error basis facing the difficulty of predicting the behavior of futures traders and stockholders in varying situations. Reliable estimates of stock redistribution and volumes of futures trading would be difficult to make.

Assumption (6), which is implicit in the proposal, seems unrealistic. It recognizes only first round effects of *CSA* actions. In a perfectly operating market the range of inter-temporal prices differs solely by the cost of carrying inventories. When $P<BP$, *CSA* action would have the first round effect of raising spot price Ps and distant future price Pn. This changes the differential between these two prices and all other inter-temporal prices. Private traders would bid all other prices up, or bid Ps and Pn back down until such time as the differences between prices represented only inventory carrying charges, not allowing for any profits from holding a particular position.

In a perfectly operating market the *CSA* would have to bid up all inter-temporal prices. This would create no incentive for redistribution of stocks through time. The question then arises as to what amount of *CSA* trading would be necessary to raise the whole spectrum of prices by enough to yield the stabilized pattern of spot prices. Monthly spot quantities of soybeans plus the monthly open interest in soybean futures would be used as the calculation base. Since open interest in soybeans is generally two or three times the monthly volume of crushings plus exports, the *CSA* would have to increase its trading 200 to 300 percent above the results shown in Table 2.

Houthakker's proposal thus appears to be internally inconsistent. On the one hand he clearly states that we need to redistribute stocks through time which would require unrelated inter-temporal prices. On the other hand, to the extent that bidding up one price creates a profit incentive for private traders to bid all other prices back in line, there may be no redistribution of stocks through time.

Working suggests that hedging has "the effect . . . of promoting the stockpiling of commodities in private hands in times of surplus, inducing the economical storage of such stocks, and prompting their release for consumption at the most appropriate times" [8, p. 555]. Further, the spot-futures price relation may be a guide in inventory control which encourages holding of surplus stocks and discourages stockholding when supplies are short [8, p. 555]. Elsewhere, Working has commented that the argument that government should carry stocks "rests in large part on ignorance of the effectiveness with which the hedging facilities of futures markets assure private carrying of stocks in about as large a volume as can be justified on purely economic grounds" [9, p. 327]. This suggests that private stockholding can stabilize prices and quantities without any *CSA* action, and Working claims that while futures markets may not produce as much flexibility of stocks as desirable, at least they operate in the right direction. Other writers [1, 5] have argued for private stockholding and futures market hedging to stabilize prices through time. *CSA* action would have some effects on all traded contracts and may result in misallocation of stocks through time [6]. This in turn may confuse price signals for both inventory and production decisions.

The roles and functions of futures market participants may be affected by the proposal. It is based primarily on the risk avoidance hedging function of futures markets and ignores trading motivated either by the possibility of basis changes or to insure a steady grain supply for processing. Further, speculators are attracted by price instability that would be reduced if the *CSA* fulfilled its objectives. In some cases futures markets have declined for lack of speculator interest [10]. The *CSA* would trade as a speculator and perhaps would merely fill the gap in the speculative side of the market vacated by private speculators as a direct result of *CSA* action.

Spot and futures prices could become increasingly unrelated as a result of the operation of the proposal. Over the period of falling prices 1954–1958 the *CSA* would continually have to roll over stocks held by private traders. To induce private traders to hold stocks over a five-year period, the contract price would have to rise continually so there would be a price-of-storage incentive to hold stocks. The *CSA* would continually have to bid up contract prices so hedgers could earn a long run return from storage and retain stocks while rolling over contract holdings.

When $P>SP$ occurred, stocks would have to be held to cover short sales. Stocks may be accumulated by direct purchase or by accepting delivery on contracts purchased while $P<SP$ prevailed. In either case the *CSA* would have been drawn into a storage program which the proposal was attempting to avoid. Some predictor more reliable than a moving average of past events would be needed to anticipate long run price trends and associated stock requirements. Problems of forecasting exist for Houthakker's proposal just as for alternative stabilization proposals.

Conclusions

Implementation of Houthakker's proposal would have caused a larger movement in annual soybean prices during the 1953–1967 period than actually occurred. The three year moving average imposed "backward looking" trends on future prices and quantities during a period when long time price trends prevailed. To make the proposal work, the government would have been drawn into some kind of acquisition and storage program, which Houthakker was seeking to avoid.

Houthakker's proposal fails to consider possible side effects on the futures market. Such a proposal could greatly change the existing structural relationships between spot and futures markets. It could reduce the ability of futures markets to evaluate likely future prices and supplies and further add to price instability suggested by this evaluation of the proposal. There could be adverse effects on other futures market participants such as processors, stockholders, and speculators in addition to farmers. The importance of expectations in the relationships between spot and futures markets would add to the complexity of effects of such a proposal.

Buying and selling limits of $IP\pm 15$ percent would reduce monthly but not annual price fluctuations. The effect on uncertainty would depend on the confidence of farmers and others that the scheme would be successful. A large educational and information effort by CSA would be required. The acceptable degree of stabilization would depend on trial and error results of operation of the scheme in the futures market, cost to the *CSA*, and political acceptability to various interest groups.

Commodities with cobweb patterns of price behavior (for example potatoes, hogs, and cattle) may be amenable to price stabilization by this method. Even then costs of storage and lack of identifiable markets, grades, and standards may limit the practicability of the proposal. Commodities with long term price trends may face problems similar to those found in this study.

The evaluation of Houthakker's proposal assumes the existence of a stability problem. In the postwar period farm incomes have been increasingly stabilized as a result of stability in the whole economy [3]. Policy makers have frequently failed to distinguish the level and distribution from the stability of farm income. Existing stabilization plans have therefore been concerned, at least partly, with raising prices. Unless Houthakker's proposal was expected to offer prices as high as those under existing farm programs, it may not be acceptable. Aside from these considerations exists the question of whether price instability adversely affects farmers. Even if there are adverse effects, this research suggests that government operations in the futures markets would not solve the problem of price instability.

References

[1] ELDER, W. A., *Risk, Uncertainty and Futures Trading Implications for Hedging Decisions of Beef Cattle Feeders*, Dept. of Agr. Econ. Staff Paper P 69-20, University of Minnesota in cooperation with USDA-ERS.

[2] EZEKIEL, M., "The Cobweb Theorem," *Quart. J. Econ.* 52:255–280, 1938.

[3] FIRCH, ROBERT S., "Stability of Farm Income in a Stabilizing Economy," *J. Farm Econ.* 46:323–340, May 1964.

[4] HOUTHAKKER, HENDRICK S., *Economic Policy for the Farm Sector*, Washington, D. C., American Inst. for Public Policy Research, Nov. 1967.

[5] MCKINNON, R. I., "Futures Markets, Buffer Stocks, and Income Stability for Primary Producers," *J. Polit. Econ.* 75:844–861, Dec. 1967.

[6] TOMEK, WILLIAM G., AND GRAY, ROGER W., "Temporal Relationships Among Prices on Commodity Futures Markets: Their Allocative and Stabilizing Roles," *Am. J. Agr. Econ.* 52:372–380, Aug. 1970.

[7] WAUGH, F. V., "Cobweb Models," *J. Farm Econ.* 46:732–750, Nov. 1964.

[8] WORKING, HOLBROOK, "Hedging Reconsidered," *J. Farm Econ.* 35:544–561, Nov. 1953.

[9] ———, "Futures Trading and Hedging," *Am. Econ. Rev.*, 18:314–343, June 1953.

[10] ———, "Price Effects of Futures Trading," Stanford University, *Food Research Inst. Studies* 1:1–31, Nov. 1960.

A Note on Some Monte Carlo Results on Non-Negative Variance Estimators for a Random Coefficient Regression Model

B. R. FROEHLICH

A consistent estimator is used as a first step in estimating variances. Since this procedure frequently gives negative values, alternatives are proposed. One of these, the quadratic programming estimator, was believed to be superior to both of the others examined in this study. The experiment does not support this conjecture.

THREE alternative non-negative variance estimators are examined here. One is formed by taking the absolute value of a negative estimate; another is obtained by truncating negative estimates at zero. These estimators are compared with each other (see also [2]) as well as with a third estimator which is derived taking account of the *a priori* knowledge that variance estimators should be non-negative. The latter procedure seems intuitively superior to the absolute value estimator discussed by Subrahmanya [8], but surprisingly this is not generally so as the Monte Carlo experiment below reveals.

The Model

Consider the following linear regression model [1, 2, 4]:

$$(1) \qquad Y_t = \sum_{k=1}^{K} Z_{tk}(\beta_k + V_{tk}) \qquad t = 1 \cdots T$$

where Y_t is an observed random variable (dependent) and Z_{tk} are known nonrandom quantities (independent); β_k is the mean response of the dependent variable to a unit change in the kth independent variable, and $(\beta_k + V_{tk})$ is the actual response of the tth observation. V_{tk} are unobserved random variables such that

$$\begin{aligned} & EV_{tk} = 0 \\ (2) \qquad & EV_{tk}^2 = \alpha_k \text{ (unknown)} \\ & EV_{tk}V_{sj} = 0 \quad \text{for } t \neq s \quad \text{or } k \neq j \end{aligned}$$

The unknown parameters to be estimated in this model are $(\beta_1 \cdots \beta_k)$ and $(\alpha_1 \cdots \alpha_k)$. Attention here is restricted to the estimation of the k unknown α's (variances). An initial unbiased variance estimator which was derived by Hildreth and Houck [4] is obtained in the following manner. Writing the above model in matrix notation, the following is obtained:

$$(3) \qquad Y = Z\beta + U$$

where

$$(4) \qquad \begin{aligned} & EU = 0 \\ & EUU' = H = \text{diag}\left(\sum_k Z_{1k}^2\alpha_k \cdots \sum Z_{Tk}^2\alpha_k) \right) \end{aligned}$$

where "diag" denotes the diagonal variance–covariance matrix of disturbances.

Consider the vector of residuals r from the least squares regression of Y on Z

$$(5) \qquad r = Y - Z\tilde{\beta} = (I - Z(Z'Z)^{-1}Z')Y = MU$$

where

$$\tilde{\beta} = (Z'Z)^{-1}Z'Y.$$

Taking expectations,

$$Er = 0$$

and

$$(6) \qquad Err' = MHM$$

from which

$$(7) \qquad E\dot{r} = \dot{M}\dot{Z}\alpha$$

where

$\dot{r} = [r_1^2 \cdots r_T^2]$ and $\dot{M}$, $\dot{Z}$ denote matrices for which each element is squared. Letting

$w = \dot{r} - E\dot{r}$ and $\dot{M}\dot{Z} = G$ and considering the case where the V's are normally distributed, the following is obtained:

$$(8) \qquad \dot{r} = G\alpha + w$$

where

$$\begin{aligned} E(w) &= 0 \\ E(ww') &= \Psi = F(G, \alpha) \end{aligned}$$

(a known function of G and α).

Applying least squares to (8), one obtains

$$(9) \qquad \alpha^* = (G'G)^{-1}G'\dot{r}.$$

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Table 1. Summary of α estimators (sample size 25)

Structure ID Number	Parameter Estimated	True Value	α^*			$\bar{\alpha}$			α°			$\hat{\alpha}$		
			Mean	Var	MSE	Mean	Var	MSE	Mean	Var	MSE	Mean	Var	MSE
1	α_1	1.0	.887	.485	.498	.923	.399	.405	.959	.352	.354	.818	.310	.343
	α_2	.2	.260	.261	.264	.337	.190	.209	.414	.157	.203	.325	.174	.190
	α_3	.5	.538	.408	.409	.582	.343	.350	.626	.305	.321	.565	.311	.315
2	α_1	1.0	.935	.682	.686	.971	.583	.584	1.008	.540	.540	.789	.343	.387
	α_2	.2	.312	.457	.469	.436	.279	.334	.560	.241	.371	.417	.238	.286
	α_3	.5	.432	.376	.382	.500	.267	.267	.578	.220	.226	.486	.251	.251
3	α_1	1.0	.980	.352	.352	.994	.317	.318	1.008	.296	.296	.852	.198	.220
	α_2	.2	.169	.237	.238	.285	.118	.125	.400	.105	.145	.281	.115	.121
	α_3	.5	.551	.837	.876	.610	.783	.795	.668	.630	.658	.604	.714	.726
4	α_1	1.0	.990	.583	.583	1.032	.449	.450	1.073	.412	.417	.855	.266	.287
	α_2	.2	.147	.400	.403	.301	.234	.244	.456	.214	.279	.286	.189	.197
	α_3	.5	.519	.501	.501	.587	.387	.395	.654	.343	.367	.567	.343	.348
5	α_1	1.0	1.081	.464	.471	1.099	.417	.427	1.117	.385	.399	.940	.283	.287
	α_2	.2	.212	.250	.250	.306	.161	.173	.400	.134	.174	.298	.153	.162
	α_3	.5	.420	.580	.514	.515	.371	.371	.610	.312	.324	.500	.342	.342
Overall Average	α_1		.975	.513	.518	1.004	.433	.437	1.033	.397	.401	.851	.280	.305
	α_2		.220	.321	.325	.333	.196	.217	.446	.170	.235	.321	.174	.191
	α_3		.490	.526	.536	.559	.430	.436	.627	.362	.379	.544	.392	.396

The estimator (9) may yield negative estimates; hence alternatives such as those suggested by Subrahmanya may be considered. The truncated biased estimator

$$(10) \qquad \bar{\alpha}_k = \max\{0, \alpha_k^*\} \quad k = 1 \cdots K$$

is a natural candidate. Another suggested estimator is the absolute value estimator (also biased)

$$(11) \qquad \alpha_k^{o} = |\alpha_k^*|.$$

A third and more appealing procedure is the restricted least squares estimator that minimizes the following sum of squares of residuals

$$(12) \qquad (\hat{r} - G\alpha)'(\hat{r} - G\alpha)$$

subject to the condition that $\alpha \geq 0$.[1] (Call this estimator $\hat{\alpha}$.) Since the latter is somewhat complicated insofar as it involves a quadratic programming solution, it is of interest to see whether the anticipated reduction in Mean Square Error over the other two is worth the effort.[2] It can be shown that α^*, $\bar{\alpha}$ and $\hat{\alpha}$ are consistent estimates. For proof of this see Hildreth and Houck [4]. Attempts to obtain the small sample distribution of the above estimators has so far not been successful. Zellner [9] has studied the distribution of a constrained estimator of the form (10) for the class of models where only one independent variable is involved and where the errors are multivariate normal of the form $U \sim N(0, \sigma^2 I)$. Hocking [5] derived the distribution of a projected least squares estimator when the estimator is constrained to lie in a bounded convex set which has a unique tangent plane at every point on the surface and the errors are of the form $U \sim N(0, \sigma^2 I)$. Unfortunately these conditions are not satisfied in the present case where $\hat{r} = G\alpha + w$.

The above model is of special interest to the econometrician (see Froehlich [1]). Before such a model can be applied, however, and until further analytic results concerning the distributions of the above estimators are forthcoming, the econometrician must extract evidence of small sample properties from Monte Carlo experiments. Part of such an experiment is discussed below.[3]

Discussion

As Table 1 reveals, the mean squared error of the absolute value estimator is smaller than

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[1] Hallberg [3] in the context of another estimation problem questions the superiority of the quadratic programming procedure relative to that of ordinary least squares. See [6] for a discussion of inequality restrictions in regression.

[2] An alternative estimator for the variances based on the principle of "Minque" by C. R. Rao [7] has been derived by the author. Although unbiased, this estimator, in a Monte Carlo study involving 1000 sets of estimates based on sample size 25 and 75, proved inferior in terms of mean squared error to the estimator α^* in every set. The nonnegative version of this "Minque" estimator has also been studied by the author [1].

[3] **Design of the Monte Carlo study:** The model studied specified that for fixed k, V_{tk} are independent and identically distributed and furthermore normal [i.e., $V_{tk} \sim N(0, \alpha_k)$]. Choosing $K=3$ with the first column of $Z=1$, one has two independent variables as well as an intercept. The study was originally designed to obtain a set of structures (combinations of factors to which the estimators may be especially sensitive), namely the pattern of the Z values and the sample size. Sample size 25 for 5 patterns of independent variables was chosen, and this was repeated for sample size 75. For each structure 100 samples of the selected sample size are drawn. For a complete description of the independent variables see [2].

Table 1. Continued (sample size 75)

Structure ID Number	Parameter Estimated	True Value	α^*			$\bar{\alpha}$			α°			$\hat{\alpha}$		
			Mean	Var	MSE	Mean	Var	MSE	Mean	Var	MSE	Mean	Var	MSE
6	α_1	1.0	1.007	.139	.139	1.010	.130	.130	1.014	.124	.125	.995	.113	.113
	α_2	.2	.208	.065	.065	.227	.054	.055	.246	.048	.050	.225	.054	.055
	α_3	.5	.465	.168	.169	.472	.160	.161	.479	.154	.155	.472	.156	.157
7	α_1	1.0	1.019	.258	.258	1.028	.235	.236	1.038	.119	.120	.944	.175	.178
	α_2	.2	.214	.161	.161	.293	.091	.099	.371	.069	.098	.288	.085	.093
	α_3	.5	.489	.143	.143	.497	.134	.134	.504	.127	.127	.494	.128	.128
8	α_1	1.0	.975	.234	.235	.992	.192	.192	1.009	.165	.165	.959	.167	.169
	α_2	.2	.177	.067	.068	.203	.053	.053	.233	.044	.045	.198	.048	.048
	α_3	.5	.497	.207	.207	.508	.195	.195	.518	.186	.186	.500	.180	.180
9	α_1	1.0	.963	.154	.156	.965	.151	.152	.966	.148	.149	.924	.130	.136
	α_2	.2	.203	.083	.083	.233	.065	.066	.263	.055	.059	.232	.065	.066
	α_3	.5	.532	.139	.140	.544	.123	.125	.556	.113	.116	.544	.122	.124
10	α_1	1.0	.973	.189	.190	.983	.165	.166	.992	.151	.151	.947	.140	.142
	α_2	.2	.204	.083	.083	.235	.063	.064	.266	.054	.058	.232	.059	.060
	α_3	.5	.492	.175	.175	.501	.164	.164	.509	.158	.159	.497	.157	.157
Overall Average	α_1		.987	.195	.196	.996	.175	.175	1.004	.141	.142	.954	.145	.148
	α_2		.201	.092	.092	.238	.065	.067	.276	.054	.062	.235	.062	.064
	α_3		.495	.166	.167	.504	.155	.156	.513	.148	.148	.501	.149	.149

that of the truncated estimator for all cases of sample size 75. For sample size 25, this is true only for the parameter value of $\alpha_1 = 1$. Note in Table 2 that only for the "small" parameter value of .2 and small sample size of 25 does the truncated estimator surpass the absolute value estimator in terms of mean-squared-error efficiency. This throws some doubt on Subrahmanya's suggestion that when the distribution (in this case, the distribution of α^*) is unspecified, it is better to use the truncated rather than the absolute value estimator.

Subrahmanya conjectures that the absolute value estimator is superior to the truncated estimator under certain conditions [8, p. 109]. These conditions were checked in the present study and found to be unreliable.

A surprising feature revealed in Tables 1 and 3 is the remarkable efficiency of the absolute value estimator in comparison with the quadratic programming estimator. For sample size 75, little difference is noted between the two. For sample size 25, the quadratic programming estimator seems to have a small superiority over the absolute value estimator on the average. Such high efficiency of the absolute value estimator was not expected, insofar as the quadratic programming procedure takes into account correct *a priori* information. Since the magnitude of the parameter value as well as the sample size clearly affects the M.S.E. of alternative estimators, further investigation is needed before a choice among them can be made.[4]

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[4] A referee has pointed out that the absolute value estimator is inferior to the quadratic programming estimator when $\alpha = o$.

Table 2. Relative efficiency of ¯ compared with α° structures*

	1	2	3	4	5	6	7	8	9	10	Average 1–5	Average 6–10	Overall Average
$\frac{MSE\alpha_1^\circ}{MSE\tilde{\alpha}_1}$	.874	.925	.931	.927	.934	.962	.508	.859	.980	.910	.918	.844	.881
$\frac{MSE\alpha_2^\circ}{MSE\tilde{\alpha}_2}$	.971	1.111	1.160	1.144	1.006	.909	.990	.849	.894	.906	1.078	.910	.994
$\frac{MSE\alpha_3^\circ}{MSE\tilde{\alpha}_3}$	.917	.847	.828	.929	.873	.963	.948	.954	.928	.970	.879	.953	.916

* This table was constructed by dividing the mean squared error of the individual elements of $\tilde{\alpha}$ into the mean squared error for corresponding elements of α°. This is done for all structures.

Table 3. Relative efficiency of α° compared with $\hat{\alpha}$[a]

	1	2	3	4	5	6	7	8	9	10	Average 1–5	Average 6–10	Overall Average
$\frac{MSE\hat{\alpha}_1}{MSE\alpha_1^\circ}$	.972	.717	.743	.688	.719	.904	1.483	1.024	.913	.940	.768	1.053	.911
$\frac{MSE\hat{\alpha}_2}{MSE\alpha_2^\circ}$	.936	.771	.834	.706	.931	1.100	.949	1.067	1.119	1.034	.836	1.054	.945
$\frac{MSE\hat{\alpha}_3}{MSE\alpha_3^\circ}$	.981	1.111	1.103	.948	1.056	1.013	1.008	.968	1.069	.987	1.040	1.009	1.025

[a] Construction of Table 3 was similar to that of Table 2.

References

[1] FROEHLICH, B. R., "Estimation of a Random Coefficient Regression Model," unpublished Ph.D. thesis, University of Minnesota, 1971.

[2] ———, "Some Estimators for a Random Coefficient Regression Model," forthcoming in *J. Am. Stat. Assoc.*

[3] HALLBERG, M. C., "Estimation of Regression Parameters with the Predicted Dependent Variable Restricted in a Certain Range: Comment," *Am. J. of Agr. Econ.* 52:615, Nov. 1970.

[4] HILDRETH, C., AND J. HOUCK, "Some Estimators for a Linear Model with Random Coefficients," *J. Am. Stat. Assoc.* 63:584–595, June 1968.

[5] HOCKING, R., "The Distribution of a Projected Least Squares Estimator," *Annals of the Inst. of Stat. and Mathematics* 17:357–362, Sept. 1965.

[6] JUDGE, G. G., AND T. TAKAYAMA, "Inequality Restrictions in Regression Analysis," *J. Am. Stat. Assoc.* 61: 166–181, March 1966.

[7] RAO, C. R., "Estimation of Heteroscedastic Variances in Linear Models," *J. Am. Stat. Assoc.* 65:161–172, March 1970.

[8] SUBRAHMANYA, M. T., "A Note on Non-negative Estimators of Positive Parameters," *Metrika* 16:107–114, Feb.-March 1970.

[9] ZELLNER, A., *Linear Regression with Inequality Constraints on the Coefficients: An Application of Quadratic Programming and Linear Decision Rules*, International Center for Management Science, The Netherlands School of Economics Report 6109, Feb. 1961.

EDITOR'S PREFACE: The following represents a brief departure from the usual *Journal* Short Article/Note format. In the paper by Wilfred Candler, Wayne Cartwright, and J. B. Penn, comparative reference is made to a report that the editors and reviewers feel is not easily obtainable. For the convenience of *Journal* readers, S. C. Thompson was invited to prepare a response that is published jointly with the Candler, *et al.* paper below.

The Substitution of Analytic for Simulation Algorithms: A Comment*

WILFRED CANDLER, WAYNE CARTWRIGHT, AND J. B. PENN

An example problem that was initially analyzed by simulation and subsequently solved analytically is presented. It is argued that simulation algorithms are not necessarily preferable to analytic procedures even when problems contain apparently intractable features. Analytic solutions to simplified problems might prove useful even when a simulation algorithm is employed.

PRODUCTION economists, in their research and consulting work, frequently encounter resource allocation problems characterized by multiple goals, decreasing average costs, and integer constraints on the levels of inputs and outputs. In general these characteristics violate the assumptions required by the analytic algorithms for which computer software is widely available, although it is often useful to solve a related but modified problem that is compatible with available software. When faced with intractable problems of this type, several economists have suggested the abandonment of analytic solution procedures in favor of simulation algorithms.[1]

An interesting example of the latter approach is contained in a paper by Thompson [8]. Thompson employed a Monte Carlo simulation algorithm in solving a small capital allocation problem that contains decreasing average costs, integer requirements, and exclusionary constraints. The purpose of the present note is to compare the simulation results reported by Thompson with the optimum solution obtained using a recently completed mixed integer programming algorithm.

Example Problem

The problem considered by Thompson is given in Table 1 with minor notational changes. The key features of the problem are as follows:

(i) The objective is to maximize annual net profit from operation of a plant;

(ii) Each machine purchased contributes 365 machine-days of service;

(iii) Two production activities, x_3 and x_5, require set-up machine services (these requirements are indicated in the table by the coefficients in parentheses);

(iv) After production has been initiated, each product has fixed per unit requirements for machine services and capital;

(v) There are upper and lower bounds on the levels of all activities;

(vi) Machines must be purchased at discrete levels; and

(vii) Exclusionary relationships exist between production activities x_1, x_2, and x_3.

The solution space of this problem is clearly non-convex. Noting that this problem is a mixed integer programming problem and hence violates the assumptions of linear programming, Thompson considered a simulation algorithm wherein Monte Carlo sampling is conducted on the levels of the activities in order to generate a large number of feasible solutions. Procedures of this type may include heuristics or other optimum seeking search techniques. In the absence of search procedures (i.e., where the levels of the variables are chosen at random), probability statements can be made about the likelihood of having a solution in the best 10 percent, 1 percent, etc., of solutions. It is much less easy to give a probability of being within 1 percent of the optimum. Significantly, the procedure cannot *identify* an optimum solution even if one has been generated, nor can it report

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[1] See, for example, Willis, Minden, and Snyder [10], Patrick and Eisgruber [6], and Lee [4].

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Table 1. Thompson's initial matrix

	Production Activities					Machine Supply Activities				
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8		
Accounting Machine Days	.8	.1	1.1(8)	3.0	1.8(5)	−365			≤	0
	.5	1.4		.2	.9(4)		−365		≤	0
	1.0	.7	1.0(19)	.1	.2(7)			−365	≤	0
Capital	1.0	1.2	2.0	.5	.8	2000	1500	2500	≤	15000
Max Profit	3.5	2.0	3.0	4.0	4.0	−270	−200	−310	=	0
Activity Max	2000	2000	2000	2000	2000	7	9	5		
Activity Min	50	50	50	50	50					

Other Constraints

(i) x_6, x_7, x_8 integer,

(ii) If $x_1 > 0$, then $x_2, x_3 = 0$,

(iii) If $x_2 > 0$, then $x_1 = 0$,

(iv) If $x_3 > 0$, then $x_1 = 0$, and

(v) $x_j = 0$, or, $50 \leq x_j \leq 2000$; $j = 1, 2, \ldots, 5$.

the proximity of any solution to the true optimum.[2]

It may be of interest to consider the explicit modeling of the above problem as an integer programming problem.

Integer Programming Formulation

An initial tableau for the integer programming formulation of the problem appears in Table 2. Though not explicit in the representation in Table 1, each of the production activities x_1 to x_5 may be zero *or* in the range 50 to 2000. Since the interest in this paper is predominantly in the modeling features which allow Thompson's problem to be represented as an integer programming problem, the derivation of Table 2 from Table 1 will be discussed in some detail:

(1) First, all restraints have been expressed as "less than or equal to"; there are no "equalities" or "greater than's."

(2) The machine supply activities (x_6, x_7, x_8) of Table 2 correspond exactly to the activities in Table 1 with the exception that upper bounds on machine supplies are spelled out explicitly in appropriate restraints.

(3) The production activities (x_1 through x_5) in Table 2 correspond to the per unit resource requirements of the corresponding activities in Table 1, exclusive of the set-up costs associated with activities x_3 and x_5.

(4) Corresponding to each production activity in Table 2, a set-up activity[3] (restricted, in the last four restraints, to being at most one) has been constructed. These set-up activities incorporate the set-up costs omitted from activities x_3 and x_5 and, when introduced at a value of one, impose lower bounds of 50 and upper bounds of 2000 on the corresponding production activities.

(5) The mutual exclusion restraints (ii) through (iv) of Table 1 appear as the top two restraints of the last restraint set. Note, for instance, that if $x_9 = 1$, then $x_{10} = x_{11} = 0$, and hence $x_2 = x_3 = 0$, and $50 \leq x_1 \leq 2000$.

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[2] Thompson [8, p. 11] claims that for his example a sample of 1000 solutions produces solutions with net profit within 2 percent of "what is believed to be" the maximum, but he gives neither the details of how the maximum was identified nor his definition of the expression "within two percent."

[3] A referee suggested that these set-up costs may not be independent. In the particular example being discussed here, they happen to be independent. In more complicated situations, the price of the machines might be dependent on the number purchased; or, in other set-up problems there might be a learning process so that the second machine could be set-up at a lower cost than the first. In these cases, additional set-up activities would need to be introduced to reflect each possible way of obtaining the required machine services.

Table 2. Initial integer programming tableau for Thompson's problem

	Production Activities					Machine Supply Activities			Set-Up Activities						
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}		
Accounting Machine Days	.8	.1	1.1	3.0	1.8	-365					8.0		5.0	≤	0
	.5	1.4		.2	.9		-365						4.0	≤	0
	1.0	.7	1.0	.1	.2			-365			19.0		7.0	≤	0
Capital	1.0	1.2	2.0	.5	.8	2000	1500	2500						≤	15000
Production Upper Bounds	1								-2000					≤	0
		1								-2000				≤	0
			1								-2000			≤	0
				1								-2000		≤	0
					1								-2000	≤	0
Production Lower Bounds	-1								50					≤	0
		-1								50				≤	0
			-1								50			≤	0
				-1								50		≤	0
					-1								50	≤	0
Machine Upper Bounds						1								≤	7
							1							≤	9
								1						≤	5
Exclusion Constraints									1	1				≤	1
									1		1			≤	1
												1		≤	1
													1	≤	1
Profit Max	3.5	2.0	3.0	4.0	4.0	-270	-200	-310						=	0
x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12}, x_{13} integer															

The integer programming formulation (as specified in Table 2) was solved with a branch and bound mixed integer programming code.[4] A solution summary of the integer problem and a comparison with simulation solutions are shown in Table 3. Extensive computational experience with the code has not yet been obtained. Upper limits on problem size have not been fully explored, but it appears the code will be reasonably efficient for problems with 80 restraints and 150 variables of which 20 would be integer. Approximate computing time for the present problem (22 restraints and 14 variables, 8 of which were integer) was 15 seconds. Twenty optimal partial, "non-integer" solutions had been found, and 19 partial solutions remained in inventory when the optimum solution was obtained.

Discussion

The problem formulated by Thompson is an example of the class of problems that may be solved using known analytic algorithms, but it can also be approached by employing simulation procedures. This does not mean to imply that an analytic approach is necessarily preferable to simulation for this or any other problem, but it does suggest that all applicable procedures be reviewed before analysis begins. As

Table 3. Solution summary of example problem solved by analytic and simulation techniques

Variable	Integer programming solution	Best simulation solution*	Linear programming solution
x_1	660.61	50.00	0.00
x_2	0.00	0.00	0.00
x_3	0.00	0.00	0.00
x_4	0.00	0.00	0.00
x_5	311.95	778.89	950.73
x_6	3.00	4.00	4.70**
x_7	2.00	2.00	2.35**
x_8	2.00	1.00	0.53**
x_9	1.00	1.00	0.00
x_{10}	0.00	0.00	0.00
x_{11}	0.00	0.00	0.00
x_{12}	0.00	0.00	0.00
x_{13}	1.00	1.00	0.48**
Objective value	1729.94	1500.56	1901.04

* Four hundred solutions from the simulation procedure were generated. The solution shown above had the largest objective value of these solutions.

** Note this "solution" is infeasible since this value has not been integerized.

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[4] See Candler [1] and Penn, Candler, and Smith [7].

Thompson pointed out, when reliable software for analytic algorithms is not available to the researcher, he may have no alternative to developing a simulation procedure. However, when codes for analytic algorithms are available or can be developed, the selection of a solution procedure becomes nontrivial. The relative costs of developing or purchasing computer codes, differences in computing time, and differences in the characteristics and volume of information generated are all relevant variables. Clearly no general statements of preference can be made,[5] at least with current knowledge, and alternative algorithms should be reevaluated in each problem situation. In any event, it is obviously crucial to identify all applicable algorithms.

Again, as Thompson pointed out, when a simulation algorithm is chosen, useful information might be generated by placing an upper bound on the solution space through solving a simplified version of the problem by readily-available analytic procedures.

In evaluating simulation procedures, the probability of getting a solution in the best X percent,[6] say 1 percent, of solutions needs to be viewed with caution:

(a) If no heuristics are used, so that it is strictly a random search, consider the following example: there are five crops to produce, which can be at levels zero to 500 acres by 50 acre increments and all other decisions follow from the levels of these five cropping activities. Then each crop can be put at 11 levels (0, 50, 100, · · · , etc.), and a total of 11^5, or 161,051 potential solutions exist. There are then 1,610 solutions in "the top one percent of solutions," and even if our solution was in the midrange by value of these solutions, *there would still be 800 better solutions*! Of course the question is: How much better?[7]

(b) If heuristics are used, one enters on the horns of a dilemma. On the one hand, since plan selection is no longer random, one cannot continue to make probability statements about the the best plan being in the best X percent of plans. On the other hand, the heuristic will *usually* increase the proportion of good plans selected. It will usually raise the expected value of plans selected. The heuristic may, however, also exclude (or reduce the likelihood of selecting) the optimum plan. Mere intuition is not sufficient to prove that the optimum plan is still in the set that may be selected. Unfortunately, raising the expected value of plans selected does not necessarily also raise the expected value of the best plan selected.

Summary

This note has presented an example of a problem that was initially analyzed by simulation and has subsequently been solved analytically. It is argued that simulation algorithms are not necessarily preferable to analytic procedures even when problems contain apparently intractable features.[8] Finally, it is suggested that the analytic solution to a simplified problem might prove useful even when a simulation algorithm is employed.

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[5] We can claim with some confidence, however, tha given equal total costs, an optimizing analytic solution will be preferable to an approximation derived from simulation.

[6] See for instance [5, pp. 402–403]. One of our reviewers emphasized that if the solution space is fairly flat, then we may be almost indifferent between any of the top 1 percent of solutions. This is correct; the question is: How often is the solution space an n-dimensional pancake and how often an n-dimensional orange?

[7] If some of the solutions are infeasible, still more caution is needed, since the assertion is now that the best simulation solution is in the best X percent of solutions (feasible and infeasible): *we are no longer making an assertion about being in the best X percent of feasible solutions*. To the extent that heuristics and prior analysis can be used to reduce the sample space, this is obviously helpful and may mean some smaller number of better solutions rather than 800 better solutions in the above example. If any infeasible plans remain in the sample space, however, we are again no longer talking of the best X percent of feasible plans.

[8] Our discussion of Thompson's problem did not consider multiple goals. However, problems with multiple goals can also be handled analytically. See Candler and Boehlje [2] and Cartwright [3].

References

[1] CANDLER, WILFRED, "Integer Programming by Modification of the Right Hand Side," Dept. of Agr. Econ., Purdue University, 1972, mimeo.

[2] ———, AND MICHAEL BOEHLJE, "Use of Linear Programming in Capital Budgeting with Multiple Goals," *Am. J. Agr. Econ.* 53:325–330, May 1971.

[3] CARTWRIGHT, WAYNE, *Multiple Goals for Project Selection in Public Research and Development*, Purdue A.E.S. J. Paper 3849, Purdue University, 1969.

[4] LEE, G. E., "Artificial Intelligence in the Predecision Process of Business Management," unpublished Ph.D. thesis, Purdue University, 1970.

[5] MAASS, ARTHUR, *et al.*, *Design of Water Resource Systems; New Techniques for Relating Economic Objectives,*

Engineering Analysis, and Governmental Planning, Cambridge, Mass., Harvard University Press, 1962.

[6] PATRICK, GEORGE F., AND LUDWIG M. EISGRUBER, "The Impact of Managerial Ability and Capital Structure on Growth of the Farm Firm," *Am. J. Agr. Econ.* 50:491–506, Aug. 1968.

[7] PENN, J. B., WILFRED CANDLER, AND L. N. SMITH, "MIP652: Users Manual and Program Documentation," Dept. of Agr. Econ., Purdue University, May 1972, mimeo.

[8] THOMPSON, S. C., *A Users Manual for Monte Carlo Programming*, Dept. of Agr. Study No. 9, University of Reading, September 1970.

[9] ———, "A Monte Carlo Technique for Investment Planning and Its Application to Pig Production Systems," unpublished Ph.D. thesis, University of Reading, 1971.

[10] WILLIS, J. F., A. J. MINDEN, AND J. C. SNYDER, "Monte Carlo Simulation of Management Systems," *Canadian J. of Agr. Econ.* 17, No. 1 Feb. 1969.

The Substitution of Analytic for Simulation Algorithms: A Response*

S. C. Thompson

Development of the Monte Carlo algorithm compared here with Mixed Integer programming (*MIP*) can be traced to Swedish work begun in 1964 by Lindgren and to Carlsson [2], who published the first mimeographed paper in 1965. Work on the first English version [3] began in 1966, and at that time, when the roles of these embryonic Monte Carlo programs (*MCP*) were being discussed, the decision to go ahead was to some extent based on a weariness of waiting for mathematicians to produce a workable *MIP*. It was anticipated, however, that a successful *MIP* would be developed, and *MCP* was not designed primarily to compete with *MIP* or *LP*. Although both types of problem *can* be handled by *MCP*, there remains a substantial number of problems which are well suited for handling by *MCP*.

The matrix used by Candler, Cartwright, and Penn [1] as an example is a tiny problem designed to demonstrate a large number of examples in a small space. As these authors point out, the problem is very suitable for solution by *MIP*. Solution of the problem by maximizing a single objective function, however, fails to bring out one aspect of *MCP* which is possibly its most significant characteristic—its ability to handle multiple objectives. Departure from a simple profit maximizing model to one, for example, which handles different levels of investment immediately transforms the model into a multiple objective problem. The existence of multiple and often conflicting objectives has led to a number of attempts at ranking and aggregating objectives to produce a single "utility" that could be incorporated in *LP* or *MIP*. Financial objectives can with some degree of success be aggregated in this way, but the method is less effective when applied to heterogeneous objectives.

Even the small matrix immortalized here by Candler, *et al.* as "Thompson's problem" has two obvious objectives: profit maximization and investment minimization. And suppose a third objective to be sought is the production for sale of the maximum number of product lines possible (a plausible objective in the manufacture of some consumer goods). It will no longer be sufficient in handling this problem to use an algorithm which calculates an optimum. Rather, a means of calculating the position of the discrete Efficiency surface relating the three objectives is required.

The Monte Carlo algorithms developed in Sweden and England are capable of estimating the position of the Efficiency surface (or hypersurface if the problem demands) with little or no computational burden beyond that needed to estimate an optimum point. Since all feasible random solutions are stored, it is merely a matter of using the sub-routine in the program which sorts and graphs Efficiency lines automatically. Figure 1 shows the Monte Carlo algorithm's estimate of the Efficiency line for each of the numbers of product lines carried by the manufacturer. These lines are not smooth but are broken in several places by discontinuities, and the plateaus so formed reflect the nonlinear nature of the matrix. The positions of the lines were drawn from a small run of 400

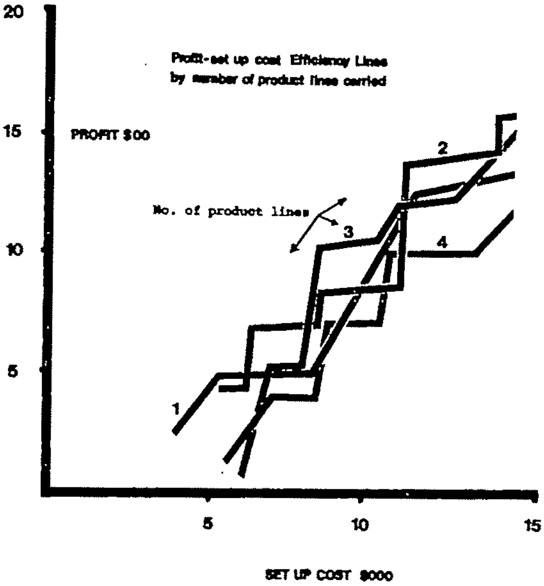

Figure 1.

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* See Editor's Preface to the preceding note.

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random feasible solutions and can only claim attention as estimates of the true positions of the Efficiency lines.

There is no doubt that a parametric *MIP* equipped with a similar sorting and graphing sub-routine could exactly locate Efficiency lines for this multiobjective problem. But two questions of current importance are, "At what cost and with what ease?" Users of presently available *MIP* algorithms point to the high cost of parametric work and to the cumbersome manner in which the algorithms must be operated. Of longer term importance is the question of increasing dimensionality when handling, for example, a dozen or so objectives. The Monte Carlo algorithm can handle large numbers of objectives with little extra effort, so that its role becomes less that of an optimum seeker and more of a portrayer of the significant relationships present in the system under study. The emphasis on an optimum (a concept which is largely illusory in agricultural systems) is thus replaced by emphasis on a "road map" from which a farmer may judge the consequences of different courses of action.

As a footnote, the English *MCP* has not remained static since its publication, and one modification in 1971 was the introduction of curvilinear relationships. The user was formerly able to specify the coefficients Q and A in the equation $y=Q+Ax$. This has been extended so that he can specify Q, A, and P in the equation

$$y = Q + Ax^P$$

where Q, A, and P can take positive or negative values.

References

[1] CANDLER, WILFRED, WAYNE CARTWRIGHT, AND J. B. Penn, "The Substitution of Analytic for Simulation Algorithms: A Comment," *Am. J. Agr. Econ.*, this issue.

[2] CARLSSON, M., "Tabeller och diagram över Monte Carlo-metodens användbarhet för studier av ekonomiska planevings-modeller," Avd. för trädgards. driftsekonomi, Lantbrukshögskolan, Alnarp, Malmö, mimeo.

[3] THOMPSON, S. C., *An Approach to Monte Carlo Programming*, Agriculture Dept. Study No. 3, University of Reading, 1967.

The Elasticity of Demand for Hired Farm Labor

T. M. Hammonds, R. Yadav, and C. Vathana

Estimation of a supply and demand model of the hired farm labor sector is presented. Elasticity estimates using this technique are compared to estimates obtained through cross–section and production function models.

A review of the literature dealing with the hired farm labor market reveals a conflict between elasticity estimates derived from models using time–series analysis and those derived from models using a cross–sectional approach. This paper updates the traditional times series models and provides additional evidence from the State of Oregon.

Several econometric studies of the hired farm labor market may be found in the literature. A summary of the demand equation wage elasticities from the more important studies appears in Table 1. The cross–section and production function studies show a much more elastic demand than earlier time–series models. In this paper a time–series model developed by Schuh [11] was applied to more recent data than used in the models of Table 1. Results indicate an actual shift in elasticity over time. This suggests that the more elastic estimates obtained with cross–section and production function studies are not merely a function of the type of analysis used.[1]

Table 1. A summary of demand elasticity studies of the hired farm labor market

Study	Data period	Short–run wage elasticity	Long–run wage elasticity
Griliches [5]	1912–1956	−0.11	−0.62
Heady & Tweeten [6]	1929–1957	−0.26	−0.37
Heady & Tweeten [6]	1940–1957	−0.48	−0.60
Schuh [11]	1929–1957	−0.12	−0.40
Schuh & Leeds [12]			
Mid–Atlantic Region	1929–1955	−0.15	−0.96
Pacific Region	1929–1955	−0.23	−0.97
Wallace & Hoover [16]	1959 cross-section	−1.43	—
Bauer [1]	1959 cross-section	−1.48	—
Lianos [7]	1950–1969 production function	−1.04	−3.51[a]

[a] Southern Plains.

The Model

A simultaneous equation model was specified, with demand being a function of real farm wage, real farm income, a time trend, and an index of productivity (technology). Supply was hypothesized to be a function of real farm wage, a time trend, the unemployment in the relevant geographic region, and the real nonagricultural wage rate. Each equation was specified in a Nerlove [8, 9] framework to allow estimation of both short–run and long–run elasticities. The structural model is well documented and will not be discussed in detail here. For the rationale behind the inclusion of particular variables, see [11]. The two equations to be estimated are:

Demand

$$Y_{1,t} = \alpha_1 + \beta_1 Y_{2,t} + \beta_2 X_{1,t} + \beta_3 X_{2,t} + \beta_4 X_{3,t} + \beta_5 Y_{1,t-1} + u_t \tag{1}$$

and

Supply

$$Y_{1,t} = \alpha_2 + \beta_6 Y_{2,t} + \beta_7 X_{4,t} + \beta_8 X_{5,t} + \beta_9 X_{3,t} + \beta_{10} Y_{1,t-1} + u_t \tag{2}$$

where:

Y_1 = Number of hired farm laborers,[2]

Y_2 = Index of composite wage rates for hired farm labor, deflated by the consumer price index,[3]

X_1 = Index of prices received by farmers, deflated by the index of prices paid by farmers,[4]

X_3 = Index of productivity (technology) in agriculture,[5]

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[1] It is important to resolve this issue. An elastic demand would have significantly different policy implications concerning farm labor unionization with its accompanying wage demands and concerning legislative action on minimum wage legislation than would an inelastic demand condition (see, for example, [3]).

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[2] [13], various issues.

[3] Index of the composite wage rate (1957–59 = 100) [14], deflated by the consumer price index (1957–59 = 100) [13].

[4] Index of prices received by farmers (1957–59 = 100) [10, 13], deflated by the national index of prices paid by farmers for productive inputs (1957–59 = 100) [13].

[5] Agriculture productivity (1957–59 = 100) [13] is used as a proxy variable for technology.

Table 2. **Simultaneous equation regression coefficients for the U. S. (1941–1969)**

Model and equation	Constant	Real farm wage	Prices received ÷ prices paid	Index of technology	Time trend	$Y_{1,t-1}$	"Corrected" nonfarm income	Unemployment rate
Dynamic:								
Demand	1927.77	−16.995 (4.0)**	8.347 (3.5)**	4.701 (1.4)*	—	.188 (.9)	—	—
Supply	1112.09	4.881 (1.0)	—	—	5.673 (.9)	.704 (3.1)**	−24.953 (4.1)**	24.705 (1.9)**

* Significantly different from zero at the 10% level; figures in parentheses = t-values.
** Significantly different from zero at the 5% level.

X_3 = Time trend dummy variable,
X_4 = Nonfarm income "corrected" for unemployment and deflated by the consumer price index,[6]

and

X_5 = Index of unemployment.[7]

Equations (1) and (2) were estimated by two-stage least squares regression, treating both Y_1 and Y_2 as endogenous variables. This model differs from Schuh's model in that unemployment replaces the civilian labor force variable in the supply equation. Since there is very high multicollinearity between size of the civilian labor force and almost all other variables included in the supply equation, this variable was omitted and unemployment was used in its place.

Results from the data period 1941–1969 are presented in Table 2.[8] A model using the civilian labor force variable instead of the unemployment variable was also tested. This model was rejected because of consistently high multicollinearity between real farm wages and the civilian labor force versus virtually no multicollinearity problems between real farm wages and unemployment. Elasticity estimates calculated at the point of means for the U. S. are shown in Table 3.

As Table 3 shows, the increase in short-run elasticity since the 1930–1958 period has been remarkably persistent. In fact, a nationwide shift to an elastic short-run demand schedule may not be far away.

Serial correlation of the error term causes inefficient estimates in standard regression models but leads to inconsistent parameter estimates in autoregressive models [4, p. 36]. The maximum likelihood estimate of the coefficient of serial correlation was obtained and tested as suggested in a recent article by Durbin [2, p. 420]. For both the demand and supply equations, the lagged residual coefficients were insignificant at the 10 percent level. It may be concluded that no serial correlation exists among the residuals.

A static model was formed by dropping the lagged dependent variable term from both the demand and supply equations. This model produced a wage elasticity estimate of −1.01 for the 1941–1969 data period. The static elasticity is between the short-run and long-run dynamic estimates. This same equation was then transformed to logarithmic form and again used the last data period. The resulting wage elasticity estimate was −0.84, compared to −0.85 using the model developed for Table 2. These results indicate that a variety of models confirm a

Table 3. **Demand elasticities for the U. S.**

Time period	Short-run elasticity	Long-run elasticity
1930–1958	− .219	− .527
1931–1959	− .335	− .545
1932–1960	− .515	− .523
1933–1961	− .533	− .540
1934–1962	− .572	*
1935–1963	− .598	*
1936–1964	− .637	*
1937–1965	− .610	− .659
1938–1966	− .734	− .827
1939–1967	− .740	− .953
1940–1968	− .725	−1.030
1941–1969	− .854	−1.052
1941–1969 at 1969 levels	−1.981	−2.441

* Omitted because of a negative and insignificant coefficient for $Y_{1,t-1}$.

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[6] Nonfarm income [15] multiplied by percent of the total labor force employed [15] and deflated by the consumer price index (1957–59 = 100) [13].

[7] Unemployment rate [15].

[8] This model was used on a progression of data periods, starting with 1930–1958 and ending with 1941–1969. Only the last data period is illustrated in Table 2. Elasticity estimates from each period will be presented.

Table 4. Simultaneous equation regression coefficients for Oregon (1951–1970)

Model and equation	Constant	Real farm wage	Prices received ÷prices paid	Index of technology	Time trend	$Y_{1,t-1}$	"Corrected" nonfarm income	Civilian labor force
Dynamic Model:								
Demand	53.62	−0.446 (2.5)**	0.040 (0.4)	0.023 (0.2)	—	0.495 (3.0)**	—	—
Supply	14.35	1.09 (1.7)*	—	—	1.41 (2.3)**	0.22 (1.2)	−0.99 (2.2)**	−0.08[a] (2.4)**
Static Model:								
Demand	83.00	−0.880 (7.2)**	0.225 (2.2)*	0.128 (1.1)	—	—	—	—
Supply	18.00	1.29 (2.2)**	—	—	1.58 (2.6)**	—	−1.16 (2.7)**	−0.10[a] (2.9)**

[a] Incorrect sign.
* Significantly different from zero at the 10% level; figures in parentheses = t-values.
** Significantly different from zero at the 5% level.

progression of the short–run wage elasticity of demand toward an elastic condition.

It appears, therefore, that the differences between cross–section studies and the time-series studies of Table 1 are not due to the type of analysis used. Rather, differences probably reflect the fact that the time–series studies were concluded just before wage elasticity of demand began a steady upturn. Given the trend identified in Table 3, it may be hypothesized that several states must be well into the elastic phase of their demand curves. This hypothesis will be tested for the State of Oregon.

Oregon's Hired Farm Labor Market

Additional data problems arise with analysis on a state basis. First, a choice of the relevant geographic region from which to draw unemployment data and nonfarm income data must be made. Since there is evidence that the population is becoming more mobile, it is assumed that regional data for these variables are appropriate. This assumption is likely to be valid for Oregon since a relatively high proportion of the farm labor force is made up of migrant workers. However, local unemployment data from earlier time periods are expected to be subject to greater error than the aggregate U. S. data would be. For this reason both a civilian labor force model and an unemployment model were tested. The unemployment model was rejected because of its poor fit for the supply equation; all supply coefficients were insignificant. Finally, the national data for prices received and prices paid by farmers, and the national technology index, were used as proxies for Oregon Data.

Statistical results for the civilian labor force model are presented in Table 4. The coefficients appear to be satisfactory with the exception of the civilian labor force variable. The fact that the civilian labor force coefficient is negative and significant indicates that this variable is probably not measuring what it was intended to measure. Since some variable of this type is theoretically important, and since the model improves only marginally when it is dropped, it was left in.

Table 5. Demand and supply elasticities for Oregon[a]

Model and equation	Coefficient of adjustment	Real farm wages		Real farm prices	
		short	long	short	long
Demand at means	0.505	−1.64	−3.25	0.14	0.32
at 1970	0.505	−2.23	−4.42	0.18	0.36
Supply at means	0.78	4.02	5.15	—	—
at 1970	0.78	5.46	6.00	—	—

[a] Dynamic model.

The time trend dummy variable was dropped from the demand equation.[9] This variable was included originally to minimize any bias in the coefficient of the lagged dependent variable which might have resulted from specification error. However, time was found to be highly correlated with productivity, and both were insignificant in the demand equation. The index of productivity was retained as a proxy for technology on theoretical grounds. Specification bias, which would have been picked up by the time dummy, should also be picked up by the productivity index due to the high correlation between the two. Time was retained in the supply equation where multicollinearity problems were less severe.

This model was also tested for serial correlation of the error term using the method outlined earlier. Lagged residual coefficients were again insignificant at the 10 percent level, indicating no serial correlation. Elasticities computed at the point of means and at 1970 levels are presented in Table 5.[10]

The important relationship to note in Table 5 is that demand is elastic, even in the short-run. The rising agricultural wage, increasing level of capital-using technology, and increasing threat of labor strikes have all contributed toward a shift away from hired farm labor. An insignificant technology variable may come as somewhat of a surprise. Agriculture can, however, shift away from hired labor even in the absence of new harvesting, thinning, or conditioning machinery. Farmers merely move to a less labor-intensive crop. Rising wages, the threat of strikes, the required upgrading of worker housing and, in some cases, the encouragement of bankers, all encourage such a move. The rapid shift away from hand-harvested pole beans and strawberries in Oregon reflects, in part, this trend. Often a shift of this type is accompanied by new technology for the replacement crop, but this need not be the case.

Conclusion

There is no conflict between the wage elasticity of demand estimates obtained from time-series and from cross-section or production function models. Both indicate that the hired farm labor market is entering an elastic phase, even in the short run. At least one state, Oregon, is already well into the elastic portion of its demand curve. The results suggest that it is important for states entering this phase to rethink policies formulated to aid farm workers during a period when demand was more inelastic.

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[9] The wage elasticity estimates for the demand equation, including time as a variable, were slightly higher than the elasticity estimates presented in Table 5. Therefore, both models would lead to the same conclusion.

[10] The rejected unemployment model mentioned earlier produced a very similar demand equation with a short-run wage elasticity of −1.44 and a long-run elasticity of −2.67.

References

[1] BAUER, L., "The Effect of Technology on the Farm Labor Market," *Am. J. Agr. Econ.* 51:605–618, Aug. 1969.

[2] DURBIN, J., "Testing for Serial Correlation in Least-Squares Regression when Some of the Regressors are Lagged Dependent Variables," *Econometrica* 38:410–421, May 1970.

[3] GARDNER, BRUCE, "Minimum Wages and the Farm Labor Market," *Am. J. Agr. Econ.* 54:473–476, Aug. 1972.

[4] GRILICHES, ZVI, "Distributed Lags: A Survey, "*Econometrica* 35:16–49, Jan. 1967.

[5] ———, "The Demand for Inputs in Agriculture and a Derived Supply Elasticity," *J. Farm Econ.* 41:309–322, May 1959.

[6] HEADY, E. O., AND L. G. TWEETEN, *Resource Demand and Structure of the Agricultural Industry*, Ames, Iowa State University Press, 1963.

[7] LIANOS, THEODORE P., "Impact of Minimum Wages Upon the Level and Composition of Agricultural Employment," *Am. J. Agr. Econ.* 54:477–483, Aug. 1972.

[8] NERLOVE, MARC, "Distributed Lags and Estimation of Long-Run Supply and Demand Elasticities: Theoretical Considerations," *J. Farm Econ.* 40:301–311, May 1958.

[9] NERLOVE, MARC, and WILLIAM ADDISON, "Statistical Estimation of Long-Run Elasticities of Supply and Demand," *J. Farm Econ.* 40:861–880, Nov. 1958.

[10] Oregon Bureau of Business and Economic Research, *Oregon Economic Statistics*, Eugene, various issues.

[11] SCHUH, G. E., "An Econometric Investigation of the Market for Hired Labor in Agriculture," *J. Farm Econ.* 44:307–321, May 1962.

[12] SCHUH, G. E., AND J. R. LEEDS, "A Regional Analysis of the Demand for Hired Agricultural Labor," *Papers and Proceedings of the Regional Science Association*, ed. M. D. Thomas, Vol. 11, Philadelphia, 1963, pp. 295–308.

[13] U. S. Department of Agriculture, *Agricultural Statistics*, various issues.

[14] U. S. Department of Agriculture, SRS, *Farm Labor*, various monthly reports.

[15] U. S. Department of Commerce, *Survey of Current Business*, various issues.

[16] WALLACE, T., AND D. HOOVER, "Income Effects of Innovation: The Case of Labor in Agriculture," *J. Farm Econ.* 48:325–336, May 1966.

Impact of Aggregation on the Estimation of Outdoor Recreation Demand Functions*

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This research indicates that aggregating data tends to cause multicollinearity and difficulty in estimating the parameters of recreation demand functions. Gains in efficiency of estimation of several hundred percent could often be obtained by using individual observations, rather than the traditional zone averages, as illustrated with an empirical example.

ALTHOUGH it has long been known that the correlation between variables tends to increase when observations are grouped efficiently [5], research on this topic was primarily motivated by an interest in measuring the efficiency of estimation of Engel curves where observations were grouped by various methods. Possibly for this reason the important implications of increased correlation for grouped variables to the case of estimation of relationships involving many explanatory variables received scant attention.

Increased correlation among several explanatory variables from aggregation leads to increased difficulties with multicollinearity. This problem could often be alleviated simply by using less aggregated data. The use of less aggregated data may also help overcome specification problems in estimating such models as the demand for outdoor recreation. These contentions will be illustrated by an empirical estimation of demand for Oregon hunting.

A Commonly Employed Demand Model for Outdoor Recreation

The most commonly employed approach for estimating outdoor recreation demand is based upon the pioneering research of Clawson [3]. This approach attempts to measure recreational benefits by first estimating the inverse relation between transfer costs and participation rates. If it is assumed that the population of consumers is essentially homogeneous from one distance zone to another, then it can be argued that consumption–transfer cost combinations trace out a demand relationship, since geographical location exerts a kind of experimental control, forcing the more distant consumers to bear heavier travel and related transfer costs.

Although some have argued that the Clawson approach is inappropriate or needs modification for one or more reasons [1, 6, 12], it has provided the basis for most estimations of outdoor recreational benefits.

One serious difficulty with the traditional Clawson approach results from the high correlation between increased distance and increased travel time, which tends to result in an underestimate of value for a particular outdoor attraction, as noted by Knetsch in 1963 [7] and recently reiterated by Cesario and Knetsch:

> Perhaps the most serious difficulty of the travel cost method, as it has been applied in the past, is a consistent bias in the derived demand curve. This difficulty results from the basic assumption that the disutility of overcoming distance is a function only of money cost. This assumption is not correct. The effect of distance is likely to be a function of the time involved in making the trip, as well as the monetary cost. . . . [2, p. 702]

Along with the increase in travel time required as distance increases, Clawson and Knetsch [4] have noted that alternative recreational opportunities also become relatively cheaper in travel and related transfer costs as distance increases. Thus a strong negative bias could be expected to result collectively from the complicating factors of increased travel time, substitute attractions, and heterogeneity of participants among the various distance zones.

Thus it appears that these recreation demand functions have been poorly specified.[1] It would therefore seem highly desirable to eliminate or

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[1] Danger of bias resulting from omission of one or more relevant variables in economic research was noted by Theil in 1957 [11]. A good, more recent statement of this problem is given by Malinvaud [9, pp. 263–266].

reduce this bias, if possible, in the model specification and demand estimation procedures.

Accounting for Increased Travel Time and Related Factors

Given the importance of increased distance on the negative factors of travel time and alternative recreational opportunities, the inclusion of a separate variable, such as travel time per distance zone, would appear to be needed. Thus, visit rate could be expressed as a function of both money and time cost. However, as pointed out by Cesario and Knetsch [2], the difficulty has been that travel costs in monetary outlay and time are usually highly correlated, making it very difficult to separate the effect of one from the other.

An attempt to separate monetary from time costs was made in the 1964 Oregon Salmon-Steelhead study [1], where days of fishing were expressed as a function of transfer costs, family income, and average distance traveled per zone. However, the standard error for the coefficient of the distance traveled variable was large, indicating an unreliable estimate of the effect of this variable. Furthermore, including average distance traveled tended to inflate the variance of the transfer cost variable because of the high intercorrelation between the two variables. Some researchers have simply omitted variables such as hours or miles traveled, perhaps not being sufficiently concerned about the resulting specification bias.

What should the researcher do when confronted by the dilemma of multicollinearity on one hand and specification bias on the other? Cesario and Knetsch [2] have suggested an ingenious method for combining transfer costs and travel time into a single interacting variable. A disadvantage of their proposal is that the researcher must assume one or more specific trade-offs between monetary cost and time by the participants; however, it is this trade-off that ideally could be estimated directly from the sample information. It appears that this problem can be solved in most cases simply by avoiding the use of grouped (average) data.

An Empirical Example

The objective of a recent study of the Oregon big game resource [10] was to estimate net economic value of the resource to big game hunters. The state was divided into five regions —northeast, northwest, central, southeast, and southwest—each with certain distinctive characteristics.

Through use of the Clawson approach usually employed on this kind of problem, participation rate–transfer cost relationships were estimated for each region. Hunters were aggregated into various distance zones, also a common procedure. For example, the sample's 248 hunter families who hunted in the Northeast Oregon region were divided into 31 zones of eight families each. A participation rate–transfer cost relationship was estimated from the 31 distance zone averages:

$$\hat{V}_j = 2.4141 - 0.008712X_{1j} - 0.007943X_{2j}.$$

$$\begin{array}{lcc} (1) & (-1.252) & (-3.749) \\ R^2 = 0.604. & & \end{array}$$

$\hat{V}_j$ denotes the predicted average number of hunter unit trips to be taken per hunting family in the jth distance zone; X_{1j} denotes the average variable transfer cost per hunter trip in the jth distance zone and includes such hunting trip expenses as ammunition, lodging, licenses, and transportation at $0.05 per mile; X_{2j} denotes the distance in miles of the jth distance zone to the Northeast Oregon hunting region. Numbers in parentheses below the coefficients are t values.[2] The coefficient for the important transfer cost variable is not significant, even at the 20 percent level. However, if all information available from the sample is utilized to fit the same function in (1) to all 248 individual observations, the following result is obtained:

$$\hat{V}_i = 2.3906 - 0.009218X_{1i} - 0.006932X_{2j}.$$

$$\begin{array}{lcc} (2) & (-4.617) & (-6.567) \\ R^2 = 0.321. & & \end{array}$$

In Equation (2), all variables are the same as for (1) except that $\hat{V}_i$ now represents the predicted number of hunter trips of the ith hunting family in the jth distance zone, and X_{1i} denotes the variable transfer cost per hunter trip of the *i*th hunting family. Thus values of the variables in Equation (1) are the zone averages of the variables in Equation (2). In contrast to the imprecise results in Equation (1), where it was difficult to disentangle the separate effects of variable transfer costs and distance, fitting of the function to individual data gives a much more precise estimate of the two separate effects, as shown by the high t values in (2). Of course, the R^2 value for (2) is lower. However, economists are usually more concerned about the reliability of the estimated structural parameters.

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[2] We also estimated the effect of other variables such as hunting success, years of hunting experience, and income. However, although most of these variables were statistically significant, they had much less effect on the estimated economic value of Oregon big game and, therefore, have been omitted here to simplify the presentation. Also, another algebraic form of the demand function, the exponential, gave better statistical results than the simple linear form. However, since the economic conclusions were similar in both cases, only the results from the linear function are presented here.

The estimated coefficient for X_1, variable transfer cost, is especially important since imputed net economic value is a function of this coefficient. Despite Knetsch's 1963 article [7], most empirical estimates of outdoor recreation demand since that time have *not* included a separate distance or travel time variable, in addition to variable cost. However, if the distance variable, X_{2j}, is omitted from Equations (1) or (2) and then the net economic value is computed by means of consumer surplus, less than one-third as much value is obtained. Thus Knetsch's argument for the importance of such a variable is substantiated, at least for Oregon hunting.

Since not much difference existed between the coefficients of Equations (1) and (3), it might seem there was no great need for using individual observations rather than zone averages. This conclusion would not hold in general, however. For example, for the Central Cascade hunting area the same linear demand function as Equations (1) and (2), fitted to individual observations, gave

$$\hat{Y}_i = 0.9439 - \underset{(-3.091)}{0.005690X_{1i}} - \underset{(-5.228)}{0.005518X_{2j}} \tag{3}$$

as compared to the same function fitted to the zone averages,

$$\hat{Y}_j = 0.9503 - \underset{(-1.847)}{0.011688X_{1j}} - \underset{(-1.818)}{0.003432X_{2j}}. \tag{4}$$

As seen in the two equations above, a discrepant result is obtained from using the traditional zone average method; the estimate of the coefficient of the transfer cost variable is probably twice too large in (4), judging from the more efficiently estimated coefficient and its variance in (3).

Reasons for Increased Efficiency

There are two main reasons for loss of efficiency by using zone averages as compared to individual observations. First, it is usually not possible to have an efficient grouping for both the variable cost and distance variables simultaneously. For transfer cost models traditionally used for estimating outdoor recreation, the grouping has usually been by distance only, which is a highly efficient grouping scheme for distance but not for the transfer cost variable.

The second main reason for loss of efficiency arises from increased intercorrelation among explanatory variables when the data are grouped or averaged. Even though important, this aspect of the problem appears to have been neglected.

The preceding remarks can be illustrated by comparing the relative efficiencies of estimation of the parameters in Equations (2) versus (1), and (3) versus (4). For the Northeast Oregon hunting region, the relative efficiency of estimation from averaged observations compared to individual observations for the transfer cost coefficient can be obtained from the ratio of the variances of the coefficients, i.e., $(.001997)^2 \div (.006958)^2 \doteq .0824$.[3] Thus the efficiency of estimation from the averaged data for the important transfer cost variable is only about one-twelfth of that possible from the use of individual observations.

A similar result is obtained by comparing the variances of the transfer cost variable for the Central Cascade hunting area, i.e., $(.001841)^2 \div (.006328)^2 = 0.0846$. Again, almost 12 times as large a sample would be needed to obtain the same precision from averaged observations as from the use of individual observations.

Relative efficiency of estimation of the distance coefficient from the use of averaged observations in the preceding equations ranged from one-fourth to one-third of that from individual observations. Thus three to four times as large a sample would be needed to obtain the same precision from the averaged data as from the individual observations.

The reason for less loss of efficiency in estimating the distance coefficient is that the data were grouped efficiently insofar as the distance variable was concerned [5]. Even so, a reduction of sample size by a factor of three to four should not be disparaged.

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[3] These standard errors were obtained directly from the O.L.S. regression printout. The standard errors could also be obtained by dividing the coefficients by their respective t values.

As noted above, loss of efficiency from averaged data can arise from the increased intercorrelation of the explanatory variables. For the Northeast Oregon region, the correlation between transfer costs and distance, r_{12}, increased from 0.4401 to 0.6947 when the data were grouped into distance zone averages. By inverting the matrices for this simple two-variable case, it can be seen that the variances of $\hat{\beta}_1$ and $\hat{\beta}_2$ are increased by a factor equal to $1/1-r_{12}^2$. Thus the increased variance for averaged data due to increased intercorrelation was equal to $[1-(.4401)^2]\div[1-(.6947)^2]\doteq 1.56$. For the Central Cascade area, increased variance for averaged data due to increased intercorrelation was $[1-(.3814)^2]\div[1-(.7743)^2]\doteq 2.13$. Increased intercorrelation played a significant role in reducing the efficiency of estimation from the averaged data, even though the degree of aggregation was not great with only about eight observations per distance zone.

Implications for Future Research

If the traditional Clawson formulation of outdoor recreation is employed, the separate effect of distance should be measured, as recommended by Knetsch and coworkers [2, 7] to prevent a specification bias in the estimation of the demand elasticity. However, to measure the separate effects of distance and other variables, the aggregation of the data into distance zone averages should be discouraged since a loss of efficiency and information is incurred by such aggregation.

It should be noted that one advantage of the traditional zone aggregation approach is that individual differences in consumer preferences within zones are mitigated. Consequently, larger R^2 values are obtained than where individual observations are utilized. For certain problems of prediction or projection of aggregate visitation rates, some researchers may still prefer to use a type of zone aggregation. However, if the objective is to measure individual effects of several variables, then the aggregation of data into distance zones would not be recommended.

Because of the substantial expected loss of efficiency from aggregation, due either to inefficiency from grouping and/or the increase in multicollinearity, aggregation of data should generally be minimized when the structural parameters of economic relationships are estimated. Current research in other areas at Oregon State University also indicates gains in efficiency of estimation by reducing the amount of aggregation of the basic data.

References

[1] Brown, William G., Ajmer Singh, and Emery N. Castle, *An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fishery*, Oregon Agr. Exp. Sta. Tech. Bull. 78, Sept. 1964.

[2] Cesario, Frank J., and Jack L. Knetsch, "Time Bias in Recreation Benefit Estimates," *Water Resources Research* 6:700–704, June 1970.

[3] Clawson, Marion, *Methods of Measuring the Demand for, and Value of, Outdoor Recreation*, Reprint No. 10, Washington, D.C., Resources for the Future, Inc., Feb. 1959.

[4] Clawson, Marion, and Jack L. Knetsch, *Economics of Outdoor Recreation*, Baltimore, The Johns Hopkins Press, 1966.

[5] Cramer, J. S. "Efficient Grouping, Regression and Correlation in Engel Curve Analysis," *J. Am. Stat. Assoc.* 59:233–250, March 1964.

[6] Edwards, J. A., K. C. Gibbs, L. J. Guedry, and H. H. Stoevener, "The Demand for Outdoor Recreation in the Bend Ranger District, Deschutes National Forest, Oregon," presented at the Natural Environments Workshop, sponsored by Resources for the Future, Inc., at Missoula, Montana, Aug. 5–6, 1971. To be published by Oregon Agr. Exp. Sta.

[7] Knetsch, Jack L., "Outdoor Recreation Demands and Benefits," *Land Econ.* 39:387–396, Nov. 1963.

[8] ———, "Economics of Including Recreation as a Purpose of Eastern Water Projects," *J. Farm Econ.* 46: 1148–1157, Dec. 1965.

[9] Malinvaud, E., *Statistical Methods of Econometrics*, Chicago, Rand McNally Co., 1966.

[10] Nawas, Farid, "The Oregon Big Game Resource: An Economic Evaluation," unpublished Ph.D. thesis, Oregon State University, 1972.

[11] Theil, H., "Specification Errors and the Estimation of Economic Relationships," *Rev. Internat'l Stat. Institute*, 25(1/3): 41–51, 1957.

[12] Wilson, Robert R., "Demand Theory: Time Allocation and Outdoor Recreation," *Southern J. Agr. Econ.* 3:103–108, Dec. 1971.

PROCEEDING PAPERS

WINTER MEETING OF THE AMERICAN AGRICULTURAL ECONOMICS ASSOCIATION
WITH ALLIED SOCIAL SCIENCE ASSOCIATIONS

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THE VALIDITY AND VERIFICATION OF COMPLEX SYSTEMS MODELS

CHAIRMAN: SAUL H. HYMANS, UNIVERSITY OF MICHIGAN

Is Verification Possible? The Evaluation of Large Econometric Models*

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CONSTRUCTION of large econometric models began in earnest during the years of World War II, although some earlier pioneering examples are available. The past two decades, however, mark the period of relatively large and sustained expenditures of energy and resources on the construction of these models. Currently, large econometric models are daily becoming more numerous, more "sophisticated," larger, and certainly more popular. This rising tide of popularity has been temporarily checked from time to time due to the occasional gross forecasting errors generated by these models, but on the whole these "credibility gaps" have been short-lived, and the increasing popularity of these devices has flowed on much like GNP and "Ole Man River." Use of large-scale econometric models for forecasting is now widespread in both government and industry. In addition, these models are used by government policy makers for the calculation of policy multipliers, the evaluation of old policies, and for the ranking of prospective new ones. Despite the central importance some of these models have assumed in decision making, the process of systematic model evaluation seems, with some noticeable exceptions, to have received relatively little attention. At the very least the problem of model evaluation has lagged behind the frenetic activity in the area of model construction. Important early work in model evaluation was done by Christ [6], Adelman [1], and Theil [28], among others, and more recently the studies of Zarnowitz, Boschan and Moore [36], Evans, Haitovsky, and Treyz [11], Haitovsky and Wallace [16], as well as the current NSF–NBER Seminar on the Comparison and Evaluation of U. S. Econometric Models [9], [12], and the recent (1969) NBER Conference on Research in Income and Wealth [17], have added considerably to our understanding of this area. Nevertheless it remains true that we still lack a clear and accepted analytical basis for the selection of proper criteria for model evaluation.[1] Indeed, except for the simplest cases (nested hypothesis) the problem of evaluation and verification of single equation models is far from solved. In this latter area, although there are many more techniques available to aid in the process of model evaluation, there seems to be, among economists, no general agreement on the meaning and purpose of model verification.

The purpose of this paper is to help clarify the notion of model verification, particularly in the empirical sciences and suggest how these considerations might "shape" our approach to the problem of the verification of large econometric models. I conclude that it is not possible to consider establishing either the truth or falsity of any theory about the structure of our economic environment, or the models that represent it, and we should instead, turn our attention to the purpose of economic theories

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[1] This state of affairs was, in part, the motivation for the NBER-NSF seminar on Criteria for Evaluation of Econometric Models. For this seminar's statement of the "state of the art," see Dhrymes, *et al.* [9].

and from these objectives develop procedures for the evaluation of econometric models. The section below considers the problem of verification in the empirical sciences; the final section confronts the issue of model verification with respect to large econometric models. Hopefully the discussion will help improve our understanding of the implications of the battery of statistical techniques we have been using.

Verification in the Empirical Sciences[2]

A scientist, whether he is a theorist or an experimenter ("verifier" or tester), is concerned with putting forward statements (hypotheses, propositions) of various types and then testing them step by step. This paper, however, is not concerned with the analysis of the act of conceiving a new idea, or just how it happens that a new scientific theory occurs to someone, but simply with one particular aspect of the overall procedure of scientific inquiry—the process of systematically testing new ideas. All new ideas, of course, must be subjected to some set of systematic tests if they are to be seriously entertained. The nature and the implication of these tests, however, differ markedly in the empirical sciences (e.g. economics) and the nonempirical sciences (e.g., formal mathematics and logic).

Testing in the empirical sciences is concerned with confronting what we may call empirical theories, or theories that can be characterized as a set of propositions which are conceivably capable of being tested by observation and/or experience. The propositions of an empirical theory, therefore, are composed of *synthetic* statements or statements whose validity depends on the facts of experience. The propositions of formal mathematics or logic on the other hand are composed of *analytic* statements, or statements that convey no information about the world of experience. These propositions are necessarily true (if free from logical contradictions) since they have no factual content. The validity of nonempirical theories therefore depends solely on definitions of the symbols they contain and the rules of deductive logic. For example, consider the following statement: "either some firms are monopolies or none are."[3] Such a statement conveys no information at all about firms, and thus no conceivable experience can refute it. This should not be taken to mean that all *analytic* statements are useless. On the contrary, they very often reveal usages and relationships which we might otherwise not be conscious of. As a simple example, consider the following proposition: "If all households are net savers and all net savers accumulate capital, then all households accumulate capital." Such a statement, while not logically refutable by any conceivable set of facts, does point to the derivable relation that all households accumulate capital. From the point of view of testing new theories or ideas, the key distinction between empirical and nonempirical theories is that the former may be free from logical contradiction and still be false. That is, empirical theories may fail, not because they are formally defective, but because they fail other types of criteria based on observation and/or experience.[4]

Even in the empirical sciences, however, it is necessary to draw a distinction between practical testing and testing in principle. There are many empirical propositions which we understand and in many cases believe, even though they have not in fact received any systematic testing. Many of these could be tested if we took the trouble, but others we could not test appropriately, even if we chose, as we lack the practical means of placing ourselves in the situation where relevant observations can be made. Thus, although it is not practically possible to test such propositions at the moment, we can specify what set of observations would be necessary to carry out our test, once we are in a position to make such observations. The proposition that, "the inner core of Jupiter is white hot," is an example of a statement that is testable only in principle since an actual test must await our ability to bore into the interior of that planet. Nevertheless this theory on the temperature of Jupiter's core qualifies as an empirical theory as its propositions are, in principle, testable by observation and experience.

In considering the appropriate set of procedures to test the propositions of an empirical theory, the first step is to ensure that the theory (set of propositions) being advanced does in fact fulfill the requirement of such a theoretical system. It should contain the following characteristics:

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[2] For a more systematic and learned discussion of this issue see Ayer [2] and Popper [27].

[3] This statement has the logical form "either X is true or X is not true."

[4] Metaphysical theories, of course, are not capable of nor in need of any type of testing. Consider the following metaphysical statement: "the Absolute enters into, but is itself incapable of evolution and progress" (F. H. Bradley, *Appearance and Reality*). One cannot conceive of either an observation which would enable one to determine whether or not the Absolute did or did not enter evolution and progress, or a logical contradiction of that statement. Such a statement is not even in principle verifiable.

(1) It should be composed of synthetic, rather than metaphysical or analytical statements. That is, the theory should represent both a noncontradictory and possible world (i.e., a world of possible experience) where the validity of each of the theories or propositions may be tested by the facts of experience. That is, it must be possible for the ideas advanced to be refuted, in some sense, by experience.

(2) The theoretical system must be distinguishable from other systems that represent the world of experience in the sense that there will be a recognizable scientific advance should the propositions "pass" the various tests.

The initial stage of testing a new theory consists of examining its various propositions along with other relevant statements to determine what logical relations exist between them such as equivalence, compatibility, and incompatibility. The logical form of the theory is then examined to determine whether it is an empirical, nonempirical, or metaphysical theory. Should all be in order at this stage, we can then begin actual testing by way of empirical applications of the conclusions (statements) which form part of or have been derived from the new theory. This next stage involves facing the problem of model verification, or the problem of deciding whether or not the model *truly* represents some specific aspect of the world of experience; when we conceive of the task of model verification as the problem of establishing the truth of a particular set of synthetic statements (empirical theory), we must next specify what set of observations will accomplish this task. However, since our world of observation and/or experience is necessarily finite, we are faced with the well-known "problem of induction," or the problem of deciding when, in the empirical sciences, singular statements (summaries of our observations) can lead to universal ones (those of our theories). It seems clear that one is never justified in inferring universal statements from singular ones regardless of how numerous are the latter. No matter how many times we observe that increases in the supply of money are inflationary, the evidence will never justify, *in a formal sense*, the conclusion that all increases in the money supply are inflationary. Similarly, no matter how many white swans we see, it does not justify the statement that all swans are white. However strong the evidence in favor of a particular set of propositions, there is never a point at which it is impossible for further experience to go against it. None of the empirical propositions of a theory are absolutely certain in the sense that their truth either has been or may be absolutely confirmed. Science, simply does not have the power to decide the truth of its statements. Moreover, empirical science cannot, on the basis of observation, establish the falsity of any empirical theory.[5] The "facts" of experience can never, on logical grounds, compel us to abandon a favorite hypothesis. Suppose we have devised an experiment to test the validity of a certain theory. All theoretical propositions state that under certain conditions a certain type of event (or observation) will occur. Thus when we make the observation predicted by the theory, it is not only the particular law that is substantiated but the existence of the requisite conditions. If we fail to make the predicted observations, we may say that conditions were not what they seemed to be and may construct a theory to explain how we were mistaken about them. Any particular instance in which a favorite hypothesis appears to be refuted can always be explained away (particularly, as we shall see below, when dealing with nonexperimental models such as econometric models), although the scientist must be careful to retain the possibility that the hypothesis may ultimately be abandoned under the "force of circumstances," or the hypothesis can no longer be considered a genuine part of an empirical theory. Any empirical proposition we are resolved to maintain in the face of any experience is not a *synthetic*, but an *analytic* proposition.

If empirical theories cannot be verified, we may also wonder how we can speak of objective scientific statements in the empirical sciences—i.e., statements that are independent of a particular investigator's whim. The objectivity of empirical theories consists only in the requirement that they be "intersubjectively testable." Thus in the empirical sciences, scientific objectivity is simply interpreted as a methodological rule. Before a set of statements and tests can be eligible for introduction into a science, it must be possible to issue a precise set of instructions that will enable other researchers to reproduce the results exactly.

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[5] There is a class of rather uninteresting empirical propositions which can be verified conclusively by observations. These are propositions which simply convey the content of a single experience, e.g., "The sun rose yesterday." However, these types of propositions hardly constitute a theory. Similarly there is a class of empirical theories whose falsity can, in principle, be established. These are collections of propositions put forward in the following way: "Under every conceivable set of conditions the following exact (nonstochastic) relationship will hold. . . ." In this latter case a single counter-example establishes the falsity of the theory. Neither of the two classes of theories, however, has any importance for the advancement of empirical science.

If science cannot decide on the truth or falsity of its theories, how do we determine which hypotheses shall be "retained" (used to guide action) and which shall be abandoned? The answer is readily available if we consider the reason for construction of theories and/or hypotheses in the first place. People may construct theories for the "fun of it," but scientists construct theories in order to help us better anticipate or forecast some aspect of our world of experience. The principle objective of new empirical theories is to enable us to make more accurate predictions. To put the matter another way, empirical theories can be thought of as rules which govern our expectation of future events. What I would suggest, therefore, is that the validity of an empirical hypothesis can be "tested" (not verified) by seeing whether it actually fulfills the function for which it was designed. An experiment designed to "test" a particular proposition can be considered a "success" and the hypothesis corroborated if the results increase our willingness to use the hypothesis as a guide to future events or as a guide to action. The scientist's desire to have an efficient set of rules for prediction induces him eventually to take notice of unfavorable observations and abandon cherished hypotheses. Thus logically constructed models and the theories they represent cannot be verified in the empirical science, nor can their falsity be established. We can, however, think of a theory as temporarily corroborated if the tests to which it has been subjected increase the degree of confidence with which we await the fulfillment of "the prediction."[6] Therefore we should not speak of verification of econometric models but of continuous evaluation or corroboration of models whereby such models are subject to a series of evaluative tests specified in the light of the particular uses to which it is desired to put the model. At best we ought to think of a model as being *tentatively* certified as a reasonable tool until it generates an error serious enough to shake our confidence or until it is replaced by a better unverified ("untrue") model. In this context evaluation becomes a problem–dependent or decision–dependent process, differing from case to case as the proposed use of the model under consideration changes. Thus a particular model may be "validated" for one purpose and not for another. In each case the process of evaluation is designed to answer the question: Is this model fulfilling the stated purpose? We can then speak of the evaluation of these models as the process of attempting to validate them for a series of purposes. Thus the motivation of model–builders or users becomes directly relevant to the evaluation of the models themselves. The "success" of a model can be measured by the extent to which it enables its user to decrease the frequency and consequences of wrong decisions. As Zarnowitz [34] has pointed out, the full application of even this more limited goal still poses very high informational requirements: the errors must be identifiable, the preferences of the decision maker and the constraints under which he operates must be available, and the cost of providing the model must be ascertained.

The Evaluation of Large Econometric Models

Construction and evaluation of large econometric models can be thought of as composed of two *interrelated* stages—formulation and estimation of model components and evaluation of the model as a whole. The first stage consists of a number of distinct activities. To begin with there is the formulation of a set of working hypotheses about the behavior of the system being modeled. At this point we use all available information—observations, general knowledge, relevant theory, and intuition. This stage also includes the specification of variables and functional relationships, sample selection, and the selection of appropriate estimation procedures.[7] In principle all specification should be done at this stage, but *a priori* information may not be rich enough to allow us this luxury. Some of the processes of model specification may have to be left until the second stage of the procedure (overall model evaluation). As with specification, the final determination of sample–size and estimation procedures may come in one of the later stages of the model building process as these latter procedures interact with the specification process. Finally, this stage also includes attempts to validate the individual hypotheses on which the model will be based subject to the limitations of existing statistical tests, and final decisions regarding the method of estimation. As noted above, there are many unresolved problems regarding the appropriate procedures (including evaluation) in the initial stage, but this paper does not address these problems. Rather, we are more directly concerned with the second stage which considers procedures for the evaluation of the model as a whole.

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[6] Needless to say, the increased degree of confidence generated by any "successful" test of a theory will depend on both the severity of the test (and previous ones) and the "degree of testability" of the theory (probability of being refuted). Nothing is simpler than to construct a theoretical system which is consistent with a certain set of facts, but this will not, by itself, fulfill the function of theories suggested above.

[7] Howrey, *et al.* [19] pointed out that the method of estimation itself may also be partially a function of the use to which the model is to be put. The evaluation of any model should, of course, include an evaluation of the estimating procedures used. We do not comment on this aspect of the evaluation process here. For an interesting discussion of this issue see [19].

Given that model evaluation is a problem–dependent process, we must begin the process of evaluation by considering the uses to which the model will be put. For example, one may accept the Box–Jenkins purpose of model building: "Parametric modeling attempts to discover the structure of a time series so that the residuals, after fitting the model, are purely random or white noise" [3]. Their suggested three–stage iterative procedure of *specification*, *estimation*, and *residual analysis* is exhaustive. For most economists, however, this approach would seem too narrow.[8] For most problems which economists concern themselves with and for which they will seek the help of large econometric models, it seems hard to escape the conclusion that the purpose of these models, one way or another, is to predict some aspect of reality. Thus we are bound, at least initially, to be concerned with either the model's retrospective predictions (historical validation) or prospective predictions (forecasting). Even where the model is being used for policy analysis with no historical counterpart to the simulated series (except for the "control" solution), our confidence in the result (our willingness to use the results for decision–making) will almost certainly depend on the ability of the model to predict both within the sample and in the post–sample period. Post–sample simulations are especially important for the purpose of hypothesis testing, as opposed to the procedures of hypothesis searching which often characterize the "data mining" of the sample period. Our tests or evaluation procedures should initially center on the ability of the data generated by "historical" simulation experiments to conform to the actual data. These simulations might be either deterministic or stochastic and either static (one period) or dynamic (multiperiod) in nature. A minimal requirement would be the comparison of the simulated data generated by a deterministic single–period simulation with the data from the actual historical record (both within and outside the sample period).

However, even if a model "passed" a somewhat more demanding test of its ability to "track" the historical record (e.g., a deterministic multiperiod historical simulation), economists normally also want to investigate whether or not the model responded to various types of stimuli in the fashion anticipated or suggested by economic theory or independent empirical observation. Quite aside from the individual hypotheses underlying particular equations in the system, economists have certain (not entirely independent) *"reduced form" hypotheses* which they would demand "acceptable" models to conform to. As a profession we seem to have developed some more or less vague ideas about the magnitudes of various impact, dynamic, and steady–state multipliers as well as some prior notions about other dynamic characteristics that the model "should" exhibit. Despite Haavelmo's early warning [14], however, we have, at least until the recent work of Howrey [20], failed to realize just how difficult such tests are to design and carry out. Almost all model evaluation procedures to date have employed nonstochastic simulation (with respect to both the equation error term and the sampling distribution of the estimated parameters) to generate the experimental data—a procedure which is inadequate in testing dynamic theories. This set of issues was partly confronted again at a recent NBER conference concerned with whether or not an existing set of models reproduced adequately the cyclical swings observed in our economic system.[9] It is difficult to catalogue what seems to be a minimal set of demands of this sort as needs and requirements vary according to the preferences and prejudices of the researcher and the actual needs of the user. In any case, constraints imposed by these demands are, given the current state of knowledge, not overly stringent. Even if we consider the case of the government expenditure multiplier, where a relatively large amount of evidence has accumulated, "acceptable" estimates of its magnitude (both impact and steady–state) vary widely among different "accepted" models of the U. S. economy (see Fromm and Klein [12]). I will devote most of my attention, therefore, to the use of predictive tests in the evaluation of these models.

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[8] This paper does not consider directly the important "optimal predictor" theories of Box and Jenkins [3], Wiener-Kalmogorov [31], and Kalman and Bucy [23], or the various techniques of exponential smoothing [4]. Although these techniques have important uses, it does not seem to this author that at the current time they can have an important role in the evaluation of economic hypotheses.

[9] Conference on Research in Income and Wealth, Harvard University, November 14–15, 1969. For a summary introduction to these issues as they arose at this conference, see [17].

We should also briefly consider, however, whether in all types of experiments the simulated data should be generated by stochastic or nonstochastic simulation procedures. Certainly stochastic simulation, if we have the necessary extra information (in practice we often ignore the problem of obtaining good estimates of the variance–covariance matrix of the disturbance process), will yield a more precise characterization of the model being used and thus increase the quality of the evaluation procedure. Further, if the model is nonlinear (most are these days), then the reduced form of the model is *not* the same as the nonstochastic solution [18]. Thus application of nonstochastic simulation procedures yields results that should not be expected to be consistent with the properties of the actual reduced form of the model. The question of whether this difference is large or not remains to be tested. Preliminary experiments with the Wharton model suggest the difference is not great, but a more recent study by Haitovsky and Wallace [14] suggests the contrary. When feasible, it seems advisable to use stochastic simulation to generate the experimental data.

Evaluation of the predictive ability of a model is essentially a goodness of fit problem. Although there are a number of well developed statistical techniques ostensibly available for this purpose (many initially developed in the experimental design literature), econometric model builders have mainly restricted themselves to simple graphical techniques (the fit "looks good") or simple summary measures (root mean square error, Theil's U Statistic)[10] of the performance of certain key variables (i.e., GNP). In a more recent paper, Haitovsky and Treyz [15] proposed a very interesting descriptive decomposition of the forecast error for an endogenous variable in a large econometric model. The decomposition identifies error components involving: (a) the structural equation explaining the variable in question, (b) the rest of the estimated structural system, (c) incorrect values of lagged endogenous variables (in the case of dynamic simulations), (d) incorrect guesses about exogenous variables (in the case of an *ex ante* forecast), and (e) failure to make serial correlation "adjustments" for observed errors. In addition, a recent study by Muench, Rolnich, Wallace, and Weiler [25] provides a framework for the study of the *ex post* forecast distributions of the reduced form of large non–linear econometric models and provides a valuable new addition to our evaluative procedures. Some attention has also been given to the development of a statistic analogous to the single–equation R^2, to be used to test the hypothesis that $\beta=0$, where β is the coefficient vector of the system of equations under consideration. An interesting and complete discussion of this issue can be found in Dhrymes [10, ch. 5]; he defines such a statistic but finds that it is dependent on the unknown covariance parameters of the joint distribution of the error terms of the system. While Dhrymes also derives an alternate test procedure regarding the goodness of fit of the reduced form, this procedure involves the restriction that the number of variables in the model (endogenous and exogenous) be less than the total number of observations—a restriction not generally fulfilled by large econometric models. The *trace correlation* statistic suggested by Hooper (based on estimates of canonical correlations) is closely related to the statistic suggested by Dhrymes, but its distribution seems quite untractable although Hooper has given an approximate expression for the asymptotic variance of the statistic. In a paper presented at the European meetings of the Econometric Society in Budapest, 1972, Carter and Nagar [5] suggested a new measure which makes use of the covariance structure of the reduced form disturbances and whose asymptotic distribution is known. This latter measure is an interesting and useful addition, but many problems still remain.

The principle technique suggested in the experimental design literature for testing goodness of fit of actual data to simulated data is the Analysis of Variance. There are, however, a number of difficulties in applying these techniques to data generated by large econometric models.

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[10] Howrey, *et al.* [19] recently suggested some difficulty with the root mean square error statistic (where small sample properties are known), particularly when used to compare structural versus autoregressive models, or sample versus post sample performance of a given model. See also [9, section III].

(a) The associated F and *Chi*-square tests depend on normality, constant variance, and *statistical independence*, conditions not generally satisfied by the data series generated by econometric models.

(b) Full factorial design for large nonlinear models (including all levels of the exogenous variables and the parameters describing distribution of the error term) quickly produces an unmanageably large number of cells if more than a few factors are investigated.

(c) It may be difficult to establish unbiased categories for classification of data. Occasionally a "natural" set of categories suggests itself. (See Zarnowitz's analysis of turning point errors [33].)

(d) In most interesting applications with large econometric models, we have what is known as a "multiple response problem." That is, we are interested in more than one characterization of the outcome of the experiment. If one wishes to use the analysis of variance, there are only two possibilities: treat the outcome as one of many experiments each with a single response, or combine all the responses (endogenous variables of interest) into a single response. This latter procedure, of course, involves the explicit formulation of the utility function of the user—a difficult but perhaps healthy situation. (For an interesting attempt to solve the multiple response problem see Fromm and Taubman [13] and Theil [28, 30].)

Other techniques common in experimental design literature are regression analysis and spectral analysis. With simple regression analysis we simply regress actual values on the predicted values of a series and test whether the resulting equations have "zero" intercepts and slopes not significantly different from unity (see Cohen and Cyert [7] and Hymans [21]). This general technique has also been extensively used by Theil [28], but as usual he has extended it and forced it to yield additional information. By regressing predicted values on actual values and actual values lagged a period, Theil is also able to investigate if predicted changes tend to be biased toward recent actual changes or not. Theil's inequality coefficient and its decomposition into elements of bias, variance, and covariance is very closely related to this type of analysis (although it refers to a regression of actual *changes* on predicted *changes*) and offers a great deal more information including some information on the tendency of the model to make turning point errors. Mincer and Zarnowitz [24] have provided some further development of Theil's procedure and have also suggested an additional measure of forecast error—the relative mean squared error. The latter is particularly interesting by virtue of its attempt to compare the costs and benefits of forecasts derived from alternative models of the economic process.

Spectral (cross-spectral) analysis is a statistical technique that can be used to obtain a frequency decomposition of the variance (covariance) of a univariate (bivariate) stochastic process. There are several ways in which spectrum analytic techniques might be used in the evaluation of econometric models. Naylor, *et al.* [26] suggest that the spectra estimated from simulated data be compared with the spectra estimated directly from actual data. Howrey [20] has pointed out that for linear models the spectrum implied by a model can be derived directly from the model and the stochastic simulation of the model is therefore not needed to make this comparison. Another application of spectral techniques is to test estimates of the structural or reduced-form disturbances for serial correlation, an important step in the Box-Jenkins modeling procedure.

Cross-spectral analysis can be used to investigate the relationship between predicted and actual values. That is, Theil procedures can be extended to the frequency domain using cross-spectrum analysis. This permits statistical testing of more general hypotheses about the relationship of actual and predicted values.

An important advantage of spectral analysis is that it is a nonparametric approach to data analysis. Thus it is a particularly useful device in situations in which little prior knowledge is available about the relationships under investigation. In addition, spectral methods do not depend on the statistical independence of the generated data points; they only require that the process generating the data be stationary to the second order. In order to discriminate among a number of similar hypotheses, a large number of observations may be required. Moreover, significance tests that are available depend on the assumption of normality of the underlying process or on a sample size that is large enough so that a form of the central limit theorem can be envoked. What little empirical experience has been accumulated in connection with the use of spectral analysis to investigate econometric models suggests that the technique can be used quite effectively to investigate certain dynamic properties of econometric models.

By way of summarizing this necessarily broad discussion, I would like to present, in outline form, the range of descriptive measures which have been found to be useful in assessing the forecasting performance and other relevant characteristics of large scale econometric models. While some of these measures can be subjected to classical statistical tests, most are—at this stage of our knowledge—merely descriptive and geared to specialized model uses. Many of these procedures can be traced to the writings of Zarnowitz and his co-workers [33, 34, 35, 36], Evans, Haitovsky and Treyz [11], Box and Jenkins [3], and Theil [28].

An Outline of Nonparametric Measures[11]

A. **Single-variable measures**
   (1) Mean forecast error (changes and levels)
   (2) Mean absolute forecast error (changes and levels)
   (3) Mean squared error (changes and levels)
   (4) Any of the above relative to:
      (a) the level of variability of the variable being predicted
      (b) a measure of "acceptable" forecast error for alternative forecasting needs and horizons

B. **Tracking measures**
   (1) Number of turning points missed
   (2) Number of turning points falsely predicted
   (3) Number of under- or overpredictions
   (4) Rank correlation of predicted and actual changes (within a subset of 'important" actual movements)
   (5) Various tests of randomness
      (a) of directional predictions
      (b) of predicted turning points

C. **Error decompositions**
   (1) Comparison with various "naive" forecasts[12]
   (2) Comparison with "judgmental," "consensus," or other noneconometric forecasts
   (3) Comparison with other econometric forecasts

D. **Cyclical and dynamic properties**
   (1) Impact and dynamic multipliers
   (2) Frequency response characteristics.

The measures outlined have been found to be suitable for a wide variety of purposes, and surely a user's confidence in any particular model would grow in proportion to the number of positive results yielded by such of these measures as seem relevant to the use in question. Several recent studies, [16, 22], and especially the Cooper–Jorgenson study [8], have made a valuable contribution by standardizing both the period of fit and the technique of estimation across alternative models prior to conducting intermodel comparisons.[13] Further, a recent paper by Fromm and Klein [12] summarizes the work of the ongoing NBER-NSF seminar in The Comparison of Econometric Models and provides both new information and new ideas in this area.

Models will be used for decision making, and therefore their evaluation ought to be tied to optimization of these decisions. The question we have to ask ourselves, then, is what series of tests and/or procedures will be sufficient to achieve a particular level of confidence in the use of a model for a certain specified purpose?

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[11] This outline is taken from [9].

[12] The procedures of Box and Jenkins [3] may be particularly powerful in helping to identify the autoregressive procedures which would best serve as "naive" alternatives to a structural model.

[13] See [19] for arguments regarding the controls needed in such standardization attempts.

References

[1] ADELMAN, I., AND F. ADELMAN, "The Dynamic Properties of the Klein–Goldberger Model," *Econometrica* 27 (1959).

[2] AYER, ALFRED JULES, *Language, Truth and Logic*, New York, Dover Publications, Inc., 1952.

[3] BOX, G., AND G. JENKINS, *Time Series Analysis; Forecasting and Control*, San Francisco, Holden-Day, 1970.

[4] BROWN, R. G., *Smoothing, Forecasting and Prediction of Discrete Time Series*, Englewood Cliffs, New Jersey, Prentice Hall, 1963.

[5] CARTER, R. A. L., AND A. L. NAGAR, *A Measure of Correlation for Simultaneous Equation Systems*, paper presented at the European meetings of the Econometric Society, Budapest, 1972, mimeo.

[6] CHRIST, CARL F., "A Test of an Econometric Model for the U. S., 1921–1947," in Universities–National Bureau Committee for Economic Research *Conference*

on Business Cycles, New York, National Bureau of Economic Research, 1951, pp. 35–107.

[7] COHEN, KALMAN J., AND R. M. CYERT, "Computer Models in Dynamic Economics," *Quart J. Econ.* 75:112–127, Feb. 1961.

[8] COOPER, R. L., AND D. W. JORGENSON, "The Predictive Performance of Quarterly Econometric Models of the United States," in *Econometric Models of Cyclical Behavior*, ed. B. Hickman, Conference on Research in Income and Wealth, Vol. 36, National Bureau on Economic Research, 1972.

[9] DHRYMES, PHOEBUS, J., *et al.*, "Criteria for Evaluation of Econometric Models," *Annals of Economic and Social Measurement*, Vol. 1, No. 3, July 1972, p. 291.

[10] DHRYMES, PHOEBUS J., *Econometrics*, New York, Harper and Row, 1970.

[11] EVANS, MICHAEL K., Y. HAITOVSKY, AND G. TREYZ, "An Analysis of the Forecasting Properties of U. S. Econometric Models," in *Econometric Models of Cyclical Behavior*, ed. B. Hickman, Conference on Research in Income and Wealth, Vol. 36, National Bureau of Economic Research, 1972.

[12] FROMM, GARY, AND LAWRENCE R. KLEIN, "A Comparison of Eleven Econometric Models of the United States," paper presented at the AEA meetings, Toronto, Dec. 1972, mimeo.

[13] FROMM, GARY, AND P. TAUBMAN, *Policy Simulations with an Econometric Model*, Washington, D. C., The Brookings Institution, 1968.

[14] HAAVELMO, T., "The Inadequacy of Testing Dynamic Theory by Comparing Theoretical Solutions and Observed Cycles," *Econometrica*, Oct. 1940.

[15] HAITOVSKY, YOEL, AND G. TREYZ, "The Decomposition of Econometric Forecast Error," mimeo.

[16] HAITOVSKY, YOEL, AND N. WALLACE, "A Study of Discretionary and Nondiscretionary Fiscal and Monetary Policies in the Context of Stochastic Macro-Econometric Models," in ed. V. Zarnowitz, *The Business Cycle Today*, National Bureau of Economic Research, 1972.

[17] HICKMAN, BERT G., "Introduction and Summary," in *Econometric Models of Cyclical Behavior*, ed. B. Hickman, Conference on Research in Income and Wealth, Vol. 36, National Bureau of Economic Research, 1972.

[18] HOWREY, E. PHILIP, AND H. H. KALEJIAN, "Computer Simulation Versus Analytical Solutions," in ed. T. H. Naylor, *The Design of Computer Simulation Experiments*, Durham, N. C., Duke University Press, 1969.

[19] HOWREY, E. PHILIP, L. R. KLEIN, AND M. D. McCARTHY, *Notes on Testing the Predictive Performance of Econometric Models*. Dept. of Econ. Discussion Paper 173, Wharton School, University of Pennsylvania, 1970.

[20] HOWREY, E. PHILIP, "Dynamic Properties of a Condensed Version of the Wharton Model," in *Econometric Models of Cyclical Behavior*, ed. B. Hickman, Conference on Research in Income and Wealth, Vol. 36, National Bureau of Economic Research, 1972.

[21] HYMANS, SAUL H., "Prices and Price Behavior in Three U. S. Econometric Models," paper prepared for the Conference on the Econometrics of Price Determination, Washington, D. C., October 30–31, 1970.

[22] JORGENSON, D. W., J. HUNTER, AND M. NADIRI, "The Predictive Performance of Econometric Models of Quarterly Investment Behavior," *Econometrica* 38: 213–224, March 1970.

[23] KALMAN, R. E., AND R. S. BUCY, "New Results in Linear Filtering and Prediction Theory," *J. Basic Engineering*, Series D 83, 1961.

[24] MINCER, JACOB, AND V. ZARNOWITZ, "The Evaluation of Economic Forecasts," in ed. J. Mincer, *Economic Forecasts and Expectations: Analyses of Forecasting Behavior and Performance*, National Bureau of Economic Research, 1969.

[25] MUENCH, T., O. ROLNICH, A. WALLACE, AND N. WEILER, "Tests for Structural Change and Prediction Intervals for the Reduced Forms of Two Structural Models of the U.S.: the FRB–MIT Model and Michigan Quarterly Models," Research Dept. Staff Rep. (WP-19), Federal Reserve Bank of Minneapolis.

[26] NAYLOR, THOMAS H., K. WERTZ, AND T. H. WONNACOTT, "Spectral Analysis of Data Generated by Simulation Experiments with Econometric Models," *Econometrica* 37:333–352, April 1969.

[27] POPPER, KARL R., *The Logic of Scientific Discovery*, New York, Basic Books, 1959.

[28] THEIL, HENRI, *Economic Forecasts and Policy*, Amsterdam North-Holland Publishing Co., 1961.

[29] ———, *Principles of Econometrics*, New York, John Wiley and Sons, 1971.

[30] ———, *Applied Economic Forecasting*, Rand-McNally, 1966.

[31] WEINER, N., *Extrapolation, Interpretation and Smoothing of Stationary Time Processes*, Cambridge, Mass., The M.I.T. Press, 1949.

[32] ZARNOWITZ, VICTOR, "Forecasting Economic Conditions: The Record and the Prospect," in ed. V. Zarnowitz, *The Business Cycle Today*, National Bureau of Economic Research, 1972.

[33] ———, *An Appraisal of Short-Term Economic Forecasts*, National Bureau of Economic Research, 1967.

[34] ———, "New Plans and Results of Research in Economic Forecasting," *Fifty-first Annual Report*, National Bureau of Economic Research, 1971, pp. 53–70.

[35] ———, "Prediction and Forecasting: Economic," *International Encyclopedia of the Social Sciences*, The Macmillan Co. and The Free Press, 1968.

[36] ———, C. BOSCHAN, AND G. H. MOORE, with the assistance of JOSEPHINE SU, "Business Cycle Analysis of Econometric Model Simulations," in *Econometric Models of Cyclical Behavior*, ed. B. Hickman, Conference on Research on Income and Wealth, Vol. 36, National Bureau of Economic Research, 1972.

Implications to and from Economic Theory in Models of Complex Systems

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THE role of economic theory in econometric models has been controversial for many years. In part this stems from the theories themselves. Disagreements between and about theories have carried over into disagreements about the econometric models into which the theories are imbedded. Attempts to discredit theories have led to broad attacks on model building, estimation methods, and simulation results. Debates on monetarist vs. Keynesian formulations on primary factors controlling output paths of the economy (for example, Friedman *vs.* Heller [26]) have had their counterparts in attacks on the usefulness of associated models—St. Louis Federal Reserve Bank [3] and Laffer-Ranson *vs.* Brookings [29], DHL [38], DRI [13], Fair [18], and Wharton [55].

Aside from disagreements about particular theories, econometric models have been challenged on a number of fundamental issues. First, there is the question raised by Liu [52] whether the world, and models that depict it, is truly underidentified and whether it is possible to specify a set of structural equations that truly represent behavioral decisions of economic entities, large or small. Second, others have argued that since the true determinants of behavior cannot be observed or measured, it is useless to attempt to construct and estimate empirical systems. For instance, Basmann has averred that discussions about Keynesian-type consumption functions are moot because these equations only indirectly reflect utilities of quantities of income, leisure, and purchases, and their use. He has maintained that since the relationship between utility and observed income and expenditure is unmeasurable, it is inappropriate to estimate consumption-income relationships.

A third point of issue centers on the problem of aggregation. There are some who believe that it only is sensible to construct models at the micro- or decision-unit level because behavior across units is disparate, and proper conditions for valid or reliable aggregation across units are unlikely to be met. In the extreme, this calls for models of individuals, families, establishments, companies, and so forth, rather than population groups, industries, regions, and the economy as a whole. Because the costs of obtaining sufficient data and estimating micro-decision-unit models are high, some analysts with this viewpoint have resorted to a second-best alternative which utilizes limited aggregation, for example, at the level of markets and population subgroups (cf. the work of Orcutt and associates [61]).

Similar reasoning has been propounded in support of small, reduced-form models of the economy as a whole, industries, or companies. The argument advanced is that it is impossible or too costly to construct complete structural or behavioral systems and that, in any event, these systems would be subjected to the same exogenous forces, albeit indirectly, as impinge on smaller, reduced-form condensations of underlying structural relationships. Therefore, supposedly it is possible to proceed directly to estimation of small reduced-form models without the intermediate step of specifying underlying behavioral or structural details.

Leaving the above issues aside, there has been skepticism about the efficacy of building empirical models when errors of measurement are great, which may prevent estimation of parameters that have acceptable statistical properties (see Morgenstern [57]). Poor data can lead to biased, inconsistent, and inefficient coefficients and solutions, particularly when little is known about measurement-error distributions of key variables.

Many of the arguments of widely different viewpoints on these issues have merit, even when the positions are extreme. For instance, ideal aggregation conditions rarely exist. Errors of measurement in national income accounts are sizable and bias forecasts and estimated equation parameters (see Cole [9]), thereby weakening the conclusions and policy prescriptions derivable from macroeconomic models. On the other hand, reduced form and aggregate-predictive rather than microbehavioral relationships may be required because economic theory is imperfect and inexact and structural specifications are incomplete.

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Other issues and limitations of economic theory and data could be cited. But rather than launch an extended debate into the nature of economic science, statistical inference, and models, a provocative but largely barren philosophical excursion, it is better to examine how model-builders have dealt with these problems in constructing complex systems that are useful for forecasting and policy analysis purposes.[1]

Theory in Models

Theory has many definitions, ranging from vague abstractions on the nature of a process to systematic and precise formulations of underlying relationships and principles that account for observed phenomena. In its least rigorous and popular form, a theory is nothing more than a hypothesis, conjecture, or supposition. From this last standpoint, every model is dependent on theory, however naive and simplistic.

Such a definition does not carry us far in being able to differentiate between models and theories. The attempt to do so flounders in nuances about the interpretation of one variable or another and its functional relationship to underlying behavior. For example, in postulating that consumption expenditures in the current period depend on income in the same period, is current income to be taken as a constraint or as an indicator of present and expected future earnings potential? This kind of question arises again and again. There are many different reasons (theories) that can be given as to why a particular variable (explanatory influence) is included in a specific equation.

Moreover, it is not unusual that a relationship specified using one theory can easily be transformed into a competing theory. For instance, in the Duesenberry-Eckstein-Fromm model [11] it was shown that the consumption function postulated under the relative-income hypothesis was equally consistent with the permanent income hypothesis. Complete system properties were unaffected by the choice of either alternative; only the interpretation of results of simulations and implications for government fiscal policy differed.

Aside from complications of the translatability of theories one into another, descriptions and assessments of the use of theory by model-builders is made more difficult because derivations of hypotheses from basic causal mechanisms frequently are completely omitted or are only vaguely indicated. General functional specifications and expected signs of coefficients often are given, but this is insufficient to link an equation with a complete theory of behavior, therefore leaving the model-user (or critic) to draw his own inferences. This is especially troublesome when the equations are full or semi-reduced forms or are justified by *ad hoc* reasoning.

In defense of model-builders, it should be noted that rarely is economic theory so rich or so encompassing that it is possible to relate micro-theory to macro-phenomena (cf. Goldberger [31, 126]). Even when micro-theory provides behavioral propositions, normally they refer to static or dynamic equilibrium states and not to the disequilibrium situations most characteristic of the real world. Most rigorous theoretical derivations of equation specifications require stringent assumptions about objective functions, the nature of uncertainty or the lack thereof, the efficiency of search processes, and convergence to desired states. In addition, when these specifications are applied to macro-economic data for empirical verification, heroic assumptions are needed to subvert aggregation difficulties.[2] Faced with these limitations, perhaps model-builders have little recourse, until theory and data are improved, than the reduced-form approximations that are so prevalent in econometric work.

Then, too, the use of theory may be greater than it appears. Many functional forms implicitly, if not explicitly, have their basis in the behavioral hypotheses that economists hold so dear. While we cannot identify the precise theory that attaches to particular functions in a variety of models, it is possible to relate the equations back to a number of primary mechanisms. These are common across a wide spectrum of models and are described below.

The Maximum Principle

Since the time of Adam Smith, economic theory has relied heavily on the maximum principle.[3] Consumers are said to maximize utility, firms maximize profits (or minimize costs), and governments maximize national welfare. In general terms, much of economic theory can be represented by:

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[1] For disparate views on the role of theory and empirical analyses, see Robbins [64], Friedman [24], and Koopmans [49].

[2] See Theil [70]. For an interesting new approach for reconciling micro and macro phenomena, see Bergmann [5].

[3] The importance of maximization in economics is illustrated in Paul Samuelson's address after being awarded the Nobel Prize [65].

$$\text{Maximize } F = f(x_1, x_2, \cdots, x_n)$$
$$\text{Subject to } g(x_1, x_2, \cdots, x_n) \leq G.$$

Consumption Functions

Consumption functions in many models implicitly are related to the linear expenditure system of Klein and Rubin [48] and Stone [67]. It is based on the utility function:

$$(1) \quad U = d\Sigma_i b_i \log (q_i - c_i a_i) \quad i = 1, \cdots, n$$

where U is utility, q's are quantities purchased, d, b's and c's are fixed parameters, and the a's can be interpreted as minimum required purchases or state variables.[4] Maximizing (1) with respect to q_i subject to a budget constraint $y \geq \Sigma_i p_i q_i$ gives:

$$(2) \qquad q_i = c_i a_i + db_i/\lambda p_i$$

where λ is the Lagrangian multiplier and represents the marginal utility of income. Multiplying (2) through by p_i and summing over all i, yields (setting the scale parameter such that $\Sigma_i b_i = 1$):

$$(3) \qquad \lambda = d/(y - \Sigma c_i a_i p_i),$$

so that

$$(4) \qquad q_i = c_i a_i + b_i(y - \Sigma c_i a_i p_i)/dp_i.$$

A large number of variations are possible from this point. For example, multiplying (4) by p_i gives

$$(5) \quad p_i q_i = c_i a_i p_i + (b_i/d)y - (1/d)\Sigma c_i a_i p_i,$$

a consumption function in current dollars similar, when expressed in rate-of-change terms, to the formulation used in the DRI Model. Dividing the numerator and denominator of the last term in (4) by Σp_i and expanding it into a linear approximation, yields

$$(6) \quad \begin{aligned} q_i = {} & b_i + c_i a_i \\ & + (b_i/d)(y - \Sigma c_i a_i p_i)/\Sigma p_i + e_i p_i/\Sigma p_i, \end{aligned}$$

which is akin to consumption equations in the Brookings, DHL, OBE, and Wharton models, where $y/\Sigma p_i$ is constant dollar disposable income (or income less transfer payments for purchases of durables). The state variables in (6) can be defined to include past consumption of q_i to represent capital stock or habituation effects. Other possible variations are to include liquid assets in the budget constraint (as in the FRB-MIT or MPS models) and to assume that a_i or $\Sigma c_i a_i = 0$.[5]

These relationships, of course, do not account for utility maximization over anticipated lifetime consumption, income, and asset streams (the Modigliani life-cycle hypothesis). Changing demographic distributions (the age-sex-family size mix) that influence aggregate consumption outlays can be incorporated as state variables (see Taubman [68] and Agrawala and Drinkwater [1]). Finally, in a dynamic setting account must be taken of expectational and inertial influences (such as permanent *vs.* transitory income, cf. Friedman [25]). This can be done by several techniques, which are described in a subsequent section on adjustment mechanisms.

Production Sector Relationships

Maximization principles play a central role in the revitalized neoclassical theory of the firm, which has gained widespread acceptance and application in the last decade, particularly for the study of investment behavior.[6] The analysis proceeds as follows. Let the production function for the firm be represented by:

$$(7) \qquad Q = F(K, L)$$

where Q is output, K is capital, and L is labor man-hours (additional input factors can be included without loss of generality) and the function satisfies the usual necessary conditions on marginal products and differentiability. Assume, too, that the firm is faced by a demand function given by

$$(8) \qquad p = G(Q)$$

and that it has the objective of maximizing profits (π)

$$(9) \quad \begin{aligned} \pi = {} & pQ - wL - cK - \lambda_1(F(K, L) - Q) \\ & - \lambda_2(G(Q) - p) \end{aligned}$$

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[4] Variations of this function provide for different definitions of the state variables. See Pollak [63] and Phlips [62].

[5] The utility function could be changed, too, to an additive quadratic as in Houthakker and Taylor [37]. However, Taylor and Weiserbs [69] have recently found that this utility form may be subject to an important satiation defect.

[6] This is attributable in large measure to the work of Dale Jorgenson, see [41], and his survey of the literature in this field [42].

where p is product price, w is labor cost per manhour, c is the rental price of capital and λ_1 and λ_2 are Lagrangian parameters.

Differentiating (9) with respect to p, Q, L, and K, and solving the resulting set of equations yields:

$$\frac{\partial F}{\partial K} = \frac{c}{p(1 + 1/e_d)} \tag{10}$$

$$\frac{\partial F}{\partial L} = \frac{w}{p(1 + 1/e_d)}, \tag{11}$$

where e_d is the price elasticity of demand.[7] Specifying the production function (7) as *CES*

$$Q = A[dK^{-\rho} + (1 - d)L^{-\rho}]^{-v/\rho} \tag{12}$$

and differentiating with respect to K, and setting the result equal to (10):

$$\begin{aligned} \frac{\partial F}{\partial K} &= dvA^{-\rho/v}Q^{(1+\rho/v)}K^{-(1+\rho)} \\ &= \frac{c}{p(1 + 1/e_d)} \end{aligned} \tag{13}$$

so that

$$K^* = (dvA^{-\rho/v})^{\sigma}Q^{\sigma(1+\rho/v)}\left(\frac{p}{c}(1 + 1/e_d)\right)^{\sigma} \tag{14}$$

where K^* is the desired capital stock.

Various simplifying assumptions now produce the gross investment functions (after allowing for dynamic adjustments and adding replacement investment) of most econometric models. Without exception, v, the economies of scale parameter, is assumed to be unity (the case of constant returns). Also, either output is assumed to be exogenously determined or the elasticity of demand is presumed to be high. Thus, (14) reduces to:

$$K^* = d^{\sigma}A^{\sigma-1}Q(p/c)^{\sigma} \tag{15}$$

where the elasticity of substitution between capital and labor $\sigma = 1/(1+\rho)$. With $\sigma = 0$, factors of production are used in fixed proportions, the assumption in early studies of investment and in the Fair Model. With $\sigma = 1$, the production function is Cobb-Douglas (assumed in the Brookings, DHL, OBE [50], and Wharton models). The Liu [53] and MPS models use a CES function with $\sigma \neq 1$ (although the elasticity is close to unity in the latter model).

The neoclassical approach and derivation above can be used to develop justifications for other production sector equations in macromodels. For example, using (11) and differentiating (12) with respect to L (with $\rho = 0$ so that $\sigma = 1$) yields:

$$\frac{w}{p(1 + 1/e_d)} = \frac{(1 - d)Q}{L^*} \tag{16}$$

or

$$p = \left(\frac{1/(1 - d)}{1 + 1/e_d}\right)\frac{wL^*}{Q} \tag{17}$$

where wL^*/Q can be interpreted as actual or normal unit labor costs, *ULC* (actual labor compensation rates multiplied by labor requirements at expected output levels), in the manner of Eckstein and Fromm [12]. The elasticity term can be interpreted as a markup factor, so that the equation can be written $p = mULC$, which, apart from dynamic adjustments, is the hypothesis imbedded in the Brookings, DHL, DRI, MPS, OBE, and Wharton models.[8]

A related approach to the analysis of production sector relationships is that pioneered by Holt, Modigliani, Muth, and Simon [36] and more recently utilized by Childs [7] and Hay [35]. Here the objective of the firm again is to maximize profits or minimize costs, but subject to a multiplicity of constraints. A set of decision rules is derived which yield optimal inventory, production, and unfilled order levels. The inventory and orders functions bear a strong resemblance to these equations in several macromodels.

Yet, as Baumol [4] and others have indicated, this type of analysis may be inappropriate for model building, especially at the level of the firm, for several reasons.[9] First, businessmen may not maximize but could instead be satisfied with acceptable profits. Second, the production function or the optimum frontier (including the demand function) may be unknown. Third, businessmen may have greater familiarity with constraints on particular inputs than with overall limitations. Fourth, in multiproduct, joint-production, joint-cost situations, there are multiple constraints and objectives, and particular constraints may not be binding (that is, are redundant or unnecessary). In other words, the firm may not desire or achieve a position on the technological production possibility frontier, but instead be inside it. In this case, programming and simulation analyses may be applied more easily than neoclassical profit maximization or decision rules. The availability of data, or lack of it, also conditions the type of analysis that can be conducted.[10]

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[7] Note that since $e_d = (\partial Q/\partial p)\ (p/Q)$, $Q\partial G/\partial Q = p/e_d$.

[8] See Hymans [39] for a similar analysis of these functions and Nordhaus [60] for a comprehensive set of price equation derivations.

[9] See Naylor [59, pp. 1–25] for a synopsis and survey of the theory of the firm and its use in corporate simulation models.

The Adjustment Process

In this brief survey, it is impossible to cover many of the theories employed in complex systems. Most are based on the concept that a desired stock or flow can be defined (say, assets, consumption, money holdings, inventories) as a function of a set of objective conditions. Neoclassical economics prescribes these as utility and profit objective functions to be maximized subject to technical and resource constraints. The desired states, of course, are not directly observable and, therefore, additional assumptions are needed if empirical verification is to be carried out.

The simplest assumption is that the economic system always is in equilibrium and that desired and actual states are identical. This is inherent in much neoclassical theory. For example, in the study of markets, Marshall postulated that discrepancies between quantities supplied and demanded would be eliminated by competitive adjustments of prices, while Walras hypothesized that changes in the level of production would be the adjusting force. The notion that the system need never be in static or dynamic equilibrium in the presence of stochastic shocks eluded both.

Present day theorists and model-builders generally are not so naive. Most empirical formulations incorporate adjustment mechanisms that allow extended periods for desired and actual states to be different, although functionally related in convergent processes. Those most commonly used have been termed adaptive expectations and partial adjustment methods (cf. Griliches [33]). Let an asterisk denote a desired state; then under a simple form of the adaptive expectations hypothesis,

$$x_{t+1}{}^* - x_t{}^* = (1 - b)(x_t - x_t{}^*) \tag{18}$$

which upon successive substitution can be written as

$$x_{t+1}{}^* = \sum_{i=0}^{\infty} (1 - b)b^i x_{t-i}. \tag{19}$$

Assume now that

$$y_t = ax_{t+1}{}^* + u_t \tag{20}$$

where u_t is a random error term. Then

$$y_t = a \sum_{i=0}^{\infty} (1 - b)b^i x_{t-1} + u_t. \tag{21}$$

Performing the Koyck transformation of multiplying (21) by b, lagging the result by one period and subtracting from (21) yields:

$$y_t = a(1 - b)x_{t-1} + by_{t-1} + u_t - bu_{t-1}. \tag{22}$$

One linear version of the partial adjustment method assumes

$$y_t - y_{t-1} = (1 - b)(y_t{}^* - y_{t-1}) \tag{23}$$

and

$$y_t{}^* = ax_t + u_t. \tag{24}$$

Thus,

$$y_t = a(1 - b)x_t + by_{t-1} + (1 - b)u_t. \tag{25}$$

There is no difference between (22) and (25) except the stochastic error term. But this is important because it influences the choice of estimation techniques, which affects the statistical properties of estimated parameters. For instance, if in (22) it is assumed that $v_t = u_t - bu_{t-1}$ is random, but in fact $u_t = ru_{t-1} + e_t$ with $0 < r < b < 1$, then there is positive serial correlation of v_t. If this is not accounted for, inefficient estimates of a and b may be obtained.

More complex forms of the adaptive expectations or partial adjustment mechanisms lead to more complicated lag distributions and estimation problems.[11] Unfortunately, economic theory provides little guidance to model builders on adjustment processes. Eisner and Strotz [15] hypothesized that lag distributions could be dependent on speed-of-response costs, but little empirical work has been done to validate their approach or to obtain data on regulatory, engineering, ordering, and delivery lags. As a consequence, reliance has been placed on a general specification such as:

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[10] It is instructive that only a limited number of econometric models of firms or industries have been constructed. Most of the studies described at a recent conference on corporate models were of the flow-chart (simulation) or programming type. See Schreiber [66]. Examples of econometric models of firms or industries may be found in Klein [46]. See also [16, 21, 58].

[11] See Aigner [2] for a review of methods of obtaining efficient parameter estimates in the presence of autoregressive moving average error patterns.

$$(26) \qquad y_t = a\Sigma L_i x_{t-i} + u_t.$$

The particular form of L_i normally is selected arbitrarily by each investigator. Aside from specific lags or moving averages, the most restrictive assumption found in most models is that L_i exhibits a geometric decay. More flexible lag distributions that have been applied provide that the parameters of L_i are generated by low-order polynomials. The nature of this arbitrarily chosen polynomial can have a marked influence on an equation's parameters and error characteristics, thereby significantly altering overall prediction performance and structural behavior of the model in which it is imbedded (cf. Maddala and Rao [54]).

Estimation Techniques

The use of theory in specifying a model has an influence on its structure and on the choice of technique by which it is estimated. For example, let the model be represented by:[12]

$$(27) \qquad Y\Gamma + XB = U$$

where Y is an nxp matrix of endogenous variables, X is an nxq matrix of predetermined variables, U is an nxp matrix of error terms, and Γ and B are pxp and qxp coefficient matrices, respectively. Assume that Γ has off-diagonal elements and is of full rank. Then a reduced form can be calculated such that

$$(28) \qquad Y = - XB\Gamma^{-1} + U\Gamma^{-1}.$$

Aside from variables included in X, theory may suggest additional instruments needed for consistent estimation.

The properties of different estimators of (27) and (28) have received extended attention and new ones periodically are proposed.[13] Ordinary least squares (OLS) estimates of (27) are known to be biased and inconsistent (but of minimum variance) while all simultaneous estimators are consistent. Direct OLS of the reduced form (28) is unbiased but may be less efficient than limited information estimation of (27). But for the small samples usually encountered in econometric work,[14] it is not yet clear which estimator is preferred. Full information methods lack robustness to specification error and cannot be applied when the number of observations, n, is less than the total number $(p+q)$ of endogenous and predetermined variables (which is the case for the BEA, Brookings, DRI, MPS, and Wharton models).[15]

More importantly, while these models are nearly linear in the parameters, they are nonlinear in many variables. There is little information about the properties of different estimators for such nonlinear, simultaneous systems. Kelejian [45] has shown that two-stage least squares is consistent, but the relative efficiency of this and other estimators remains to be determined.[16]

Macro-econometric Models: A Survey

Different approaches to the use of theory in the specification and estimation of models are illustrated by a tabular survey prepared from materials submitted by participants in a model comparison seminar jointly sponsored by the National Science Foundation and the National Bureau of Economic Research. The ten models surveyed below differ in scale, purpose, and internal emphasis. Some of the disparities are great. Yet interchanges between model-builders and the continuing nature of model building have resulted in strikingly similar treatment in a number of areas (see Tables 1 and 2).[17]

The information content of the models should be assessed on various bases—the number of stochastic equations (especially those with feedbacks on complete system properties), the number of exogenous variables and their ratio to stochastic and total variables, the number and importance of truly endogenous variables that are treated as exogenous, the extent of structural detail (including number of policy instruments), and the degree of reliance on anticipations or attitudes data.[18]

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[12] The notation follows that of Brundy and Jorgenson [6].

[13] For example, Brundy and Jorgenson [6] have recently devised consistent and efficient limited- and full-information instrumental variable estimators for this system. Shortly thereafter Fair [19] extended these to cases in which U exhibits autoregressive errors.

[14] See Johnston [40, 408–20], Christ [8, 477–81 and 570–71], and Fair [19].

[15] Cf. Klein [46].

[16] Brundy and Jorgenson [6] used Liu's quarterly model [51] to test their estimators, but this system is almost perfectly linear in Y. The nonlinear model tests of Goldfeld and Quandt [32] were shown by Edgerton [14] to be in error. Mitchell's comparison of principal components and instrumental variable estimators with the Brookings model were inconclusive on the merits of either technique, see [56].

[17] This is a slightly revised and condensed version of tables presented earlier by Fromm [27].

Additional noteworthy features of the models may be found in Table 2. As can be seen, the Fair and DHL III models are primarily designed for forecasting, but the BEA, DRI, and Liu-Hwa models also include this as a prime objective. The St. Louis model, which is a highly-condensed reduced form, has the avowed purpose of simulating short- and long-run trends under alternative monetary and fiscal policies. When these are held constant, the results have been interpreted as predictions, although the model is not designed for forecasting in the usual sense. The MPS model, which has a substantial structural orientation, also is intended for examining the influence of fiscal and monetary policy actions but has been used for forecasting at the Federal Reserve Board. The chief aim of the Brookings model project is to advance the state of the art; specifications and approaches of this model are in part incorporated in other medium- and large-scale systems.

Various models utilize a number of different and interesting techniques in the specification of the same sectors. For example, the Fair model has disequilibrium demand and supply functions for housing starts, the BEA model has a short-run employment function which converges to a Cobb-Douglas production relationship at full capacity utilization, and the Brookings model converts industry prices to GNP component prices via an input-output matrix.

As might be expected from their qualitative differences in structure and specification, the models reveal significant disparities in their income, interest rate, and price elasticities. To some extent this is due to choices of sample periods and estimation techniques. None of the models has an identical sample period (although all except the old Wharton model begin after the Korean War). Five models (MPS, BEA70, FRB St. Louis, DRI, and Brookings) rely primarily on ordinary least squares (OLS) estimation of coefficients while the rest employ OLS and instrumental variables or two-stage least squares (TSLS) throughout. Additionally, the MPS model averts serial correlation of residuals by applying first-order autoregressive corrections to a majority of its stochastic equations.

Consequently, if sample periods and estimation techniques have a significant influence on coefficients, which previous experience reveals is the case, then intermodel comparisons of parameters are subject to question. Nevertheless, it is surprising that several models reveal marginal propensities to consume (mpc) that, *a priori*, might be considered low, both in the short and in the long run. The short-run mpc's of the BEA, MPS, and old Wharton models are about 0.4, and their long-run mpc's are approximately 0.7–0.8 (those for the Liu-Hwa model are even lower). The mpc's for the DRI, Brookings, and DHL III models are somewhat higher in the short run and, in the long run are closer to 0.9–1.0 than the other models.

Information submitted on investment, money demand, and import elasticities at this juncture is incomplete and few conclusions can be reached. Signs of these elasticities accord with traditional theory. The most striking result for investment in plant and equipment is the low long-run interest elasticity of such expenditures in most of the models. For the MPS model, which uses a rental price of capital variable, this elasticity was estimated to be about −0.4 in 1958 and 1965.

Participants in the model comparison seminar have provided a heretofore unavailable set of complete system solution prediction root mean square errors (RMSE) within and outside sample periods. These show great similarity across models within sample periods of fit (a partial set of results is tabulated in Fromm and Klein [30]). For nominal GNP, the RMSE for one period solutions are about $3–4 billion for a 1961–67 solution interval, slightly less than a simple second-order autoregressive scheme. The models exhibit a buildup in RMSE as the number of solution periods is increased, but the RMSE grow at a gradual rate.

For most of the models, the RMSE for real GNP are lower than for nominal GNP. This can be explained by errors in predicting prices, which generally tend to drift (with an upward bias). In percentage terms the errors for nominal and real GNP in initial solution quarters range around 1 percent of the levels of these variables. Percentage errors are of comparable magnitude for other expenditure and income items (except inventory change). Within-sample errors of course are downward-biased measures of post-sample accuracy. Depending on the model, the RMSE are about twice as great outside sample periods as within sample periods for one-quarter solutions, and then grow larger. However, this mainly is due to bias; first-difference errors do not exhibit strong growth trends but are stable.

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[18] Several studies have found that anticipations or attitudes add little or nothing to the explanation of consumer expenditures when a proper set of objective variables is used. See, for example, Juster and Wachtel [44].

As noted by Fromm and Klein [30], "We are beginning to converge on a common and acceptable range of errors for respectable models . . . and shall soon be able to associate tolerance (confidence) intervals with point forecasts." While for unconditional forecasting these may not be superior to less elaborate methods (see Haitovsky and Treyz [34]), models have the

Table 1. Structure of the models

Name Estimation Technique	Number of Equations • Stochastic • Identities	Number of Variables* • Endogenous • Exogenous	Principal Exogenous Variables and Policy Instruments	Disaggregation of Production Sector	Endogenous Variables Expenditure Sector Financial Sector
BEA 70 OLS with first-order serial correlation	58 41	98 83	• Govt. Exp. Tax rates, nonborrowed reserves, discount & time deposit ceiling rates, reserve requirements • Exports, Military Imports, P&E Anticipations, farm imports & Auto-price deflator, Interest Payments • Depreciation (current $) • Population • 14 Policy Instruments	• Private GNP • General Govt. (Compensation)	13 { 5 Consumption 3 Residential Construction (2 starts and 1 expenditure eq.) 1 P&E Investment (2 alternatives, Anticipation based eq.) 2 Inventory (Business, Auto & Nonauto) 2 Imports (Merchandise, Other) 10 { 6 Interest Rates 4 Assets
Brookings Condensed (1970) OLS	81 86	167 117	• Govt. expenditures, tax rates (by type) • Nonborrowed reserves, reserve requirements, discount rate • Population • Miscellaneous • 19 Policy Instruments	• Mfg. • Nonfarm, nonmfg. • Agriculture (exogenous) • Govt. enterprices (exog.) • Total GNP	21 { 4 Consumption 2 Business fixed investment (Mfr; nonfarm, nonmfg.) 2 Inventory investment 8 Residential investment 3 Import 3 Export 7 { 3 Interest rates 4 Assets
DHL III (1972) OLS and TSLS for output and factor shares	24 20	47 26	• Govt. expenditures, tax rates, transfers • Exports • Govt. purchases and gross auto product implicit • Unborrowed reserves • 7 Policy Instruments	• Total GNP • Goods • Services	8 { 3 Consumption 1 Business fixed investment 2 Residential investment 1 (Starts, expenditures) 1 Inventory investment 1 Imports 3 { 3 Interest rates
DRI (1970) OLS (TSLS for 1971 version)	200 168	368 120	• Govt. expenditures, transfers, tax rates • Nonborrowed reserves, maximum CD rate • Industry tax rates and capacity • Potential GNP • Exports • Population & marriages • Export & import prices • 29 Policy Instruments • (excluding industry tax rates)	• Total prod'n. (GNP) • Mfg. • 40 SIC industries (final recursive block)	18 { 11 Consumption 3 Fixed investment (residential, PDE, nonresident. construction) 1 Housing starts 1 Imports 1 Inventory investment 1 State & local exp. 14 { 7 Interest rates 5 Deposits 1 Stock market price 1 Commercial loans
Fair TSLS with first-order serial correlation	14 6	19 16	• Deposit flows into S&L's and MSB's • Mortgage rate • Exports • Govt. sector and agricultural sector • Population • Expectational variables • 3 Policy Instruments	• Private nonfarm	7 { 3 Consumption 1 Fixed investment 1 Housing investment 1 Business Inv. investment 1 Import No Financial Sector
FRB St. Louis OLS with Almon wts.	5 4	9 4	• Change in M_1 • Change in high-employment Fed. Exp. • Potential GNP in 58$ • 2 Policy Instruments	• Total GNP	1 { Reduced form equation for change in nominal GNP 2 Interest rates
MPS (Fed-MIT) Primarily OLS (some IV)	64 113	177 119	• Agricultural sector • Fed. Govt. Exp. and Fed • Monetary base, discount rate, reserve requirements, regulation Q ceilings, FHLBB advances & rates FNMA mortgage purchases • Population • Import prices, foreign capacity • Exports • 29 Policy Instruments	• Nonfarm private business	12 { 2 Consumption 5 Fixed investment (Equipment, structures, 182 family housing starts 3+ family housing starts housing exp.) 3 State & local govt. exp. 1 Inventory 1 Imports 30 { 6 Interest rates; 12 mtg. mkt. 9 Money supply-demand 1 Div/Price ratio; 2 coml ln.

Table 1. Continued

Name Estimation Technique	Number of Equations • Stochastic • Identities	Number of Variables* • Endogenous • Exogenous	Principal Exogenous Variables and Policy Instruments	Disaggregation of Production Sector	Endogenous Variables Expenditure Sector Financial Sector
Wharton (old) TSLS with 12 principal components	47 52	99 39	• Agricultural sector • Policy var. (Govt. exp. discount rate, net free reserves/total reserves social security contributions) • World trade index, world prices • Population • Productivity trend • 7 Policy Instruments	• Mfg. • Nonmfg. (nonfarm nonhousing private sector)	3 Consumption 3 Investment (mfg. regulated and commercial) 13 { 2 Inventory (Mfg., nonmfg.) 1 Housing 1 Exports 3 Imports 2 Interest rates
Wharton Mark III OLS and TSLS	67 134	201 104	• Corporate tax rates by sector • Nonborrowed reserves, rediscount rate • Required res. ratio, personal tax rate • Indirect tax rates (separate treatment of Fed and S&L taxes) • Investment tax credit, depreciation useful lives, Social Security tax base and rate • 25 Policy Instruments (including 6 industry tax rates)	• Mfg. • Regulated • Commercial • Govt. • Mining (exog.) • Agriculture (exogenous)	4 Consumption 3 P&E Investment (Mfg. & Mining, regulated, commercial) 13 { 2 Inventory (Mfg., Dealer Inv.) 1 Housing 1 Exports 2 Imports 5 Assets 11 { 5 Interest rates 1 Commercial loans
Liu-Hwa Hendry estimation method	42 59	101 14	• Govt. exp., tax rates • Consumer price index on food • Ratio of free to required reserves • Exports—Imports • 12 Policy Instruments	• Private nonfarm • Genl. govt.	4 Consumption 8 { 3 Fixed investment (equipment, structures, housing) 1 inventory investment 6 { 4 Assets 2 Interest rates

* Note: The total number of equations plus identities may be larger than the number of endogenous variables due to disequilibrium and alternative specifications.

advantage of conditional policy and structural analytical capabilities.

From Models to Theory

Deductive theories of economic processes give rise to models which, in turn, can be manipulated in generalized form (that is, without specific parameters) to produce additional theoretical insights. Econometric models benefit from such deductive models. But the flow from deductive theory is not necessarily unidirectional. Solutions of complex econometric systems can lead to improvements and modifications of theory.

Solutions and simulations prepared for the model comparison seminar provide a number of suggestive results. For example, there seems to be little evidence that small models exhibit markedly superior predictive performance than large models. This conclusion is buttressed by the study of Fromm and Schink [28] in which prediction errors of condensed and large versions of the Brookings model (with standardized sample periods, estimation methods, and structure) were compared over a common simulation period; the larger model proved superior.

Also, calculation of dynamic multipliers over a 10-year interval may shed some light on the amount of stimulus from alternative monetary and fiscal policy actions. Results from the seminar's simulations show that, with the exception of the FRB St. Louis model, there is a good degree of agreement between models as to fiscal impacts (see Fromm and Klein [30]). One of the most interesting findings is that constant dollar GNP-government expenditure multipliers increase in a fluctuating path but then begin to decline and even become negative after a number of years. This phenomenon is not explained by monetary stringency (other simulations were run with the same fiscal actions and with interest rates held constant). Textbook discussions of multipliers generally depict expenditure multipliers approaching positive asymptotes. Theory offers little to account for these empirical results, which are common to several models. Additional simulations may provide the answer to this conflict with conventional wisdom.

Policy analysis and theory also may benefit from simulations, see Theil [70], Fromm and Taubman [29], B. Friedman [23], and Treyz [72]. Without empirical verification, however, there is little assurance that the results of such exercises are reliable, or that they should be applied for normative or policy purposes.[19] Criteria for the evaluation of models have received only limited attention (see Dhrymes, *et al.* [10]), and available methods for selecting among alternative hypotheses lack statistical power. Validation is essential if econometric models are to have appreciable impacts on theory and decisions of policy makers. The work of the NBER-NSF model comparison and criteria seminars is a step in that direction.

Table 2. Structure of models: purpose and special features

Name	Special Intention in the Structure of the Model	Special Features in the Specification of Equations
BEA 70	Building a structural Keynesian-type model augmented by wage-price equations for short-term forecasting and policy analysis.	1. P&E investment lag structure, determined by convolution of decision to appropriation and appropriation to expenditure lag weights. 2. Short-run employment function which converges to Cobb-Douglas production function only at full capacity. Also involves variable speed of adjustment. 3. Model recomputes overall price deflator from components, thus allowing for mixed effects. 4. Solves for statistical discrepancy as residual item and allocates excessive change among income components. 5. Boundary constraint on maximum net borrowed reserves.
Brookings Condensed (1970)	Designed to integrate industry detail into simultaneous structure of the model (condensed model collapses some detail). Objective is to advance state-of-the-art of model building and policy analysis rather than emphasize short-term forecasting.	1. Use of input-output analysis as an integral, simultaneous output and price determinant. 2. Disaggregated housing sector. 3. Balance-of-payments sector (highly disaggregated in complete model).
DHL III (1972)	Designed for short-run forecasting.	1. Three main blocks—supply, expenditures, and income shares. 2. Compensation via a Phillips-Lipsey mechanism. 3. Prices depend on expected unit labor costs. 4. Investment a stock-adjustment mechanism (same approach used for consumer durables).
DRI (1970)	Designed to provide a coherent view of future developments of U. S. economy. (Forecasting for eight quarters; longer term forecasts, too)	1. Aggregate equation for corporate profits. 2. Industry detail as a recursive block (production, sales, profits). 3. Short-term interest rates determine other rates via emphasis on short-term money markets. 4. Breakdown of unemployment rates by age, sex, and race. 5. Consumption functions are in current dollar terms.
Fair	Model designed primarily for forecasting purposes. Attempt has been made to make maximum use of expectational variables. Model designed to try to minimize error compounding.	1. Employment sector based on concept of excess labor. 2. Housing sector specified and estimated under disequilibrium. 3. Direct estimation of potential GNP in the price-sector assumptions. 4. Expenditure equations are in current dollar terms and GNP is taken to be the income variable in the consumption and investment equations (no income side).
FRB St. Louis	Structure not specified because empirical relationships are sought for purposes of estimating the impact of alternative monetary and fiscal policies. Though used to give general information on short-end long-run economic trends, the model is not designed for forecasting in the usual sense of the word.	1. Expenditure equation is linear in first differences with distributed lag weights. 2. Price equation is linear in demand pressure variable (change in nominal GNP minus GNP gap) and weighted sum of past price changes in potential GNP. 3. Unemployment rate is linear function of GNP gap as a percent of potential GNP. 4. Interest rates are linear in rates of change of money, real GNP and GNP deflator.

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[19] This is one of the most troublesome aspects of the work of Forrester [22], whose deductive model simulations (with assumed parameters) have been widely publicized notwithstanding that their accuracy or validity has never been determined.

Table 2. Continued

Name	Special Intention in the Structure of the Model	Special Features in the Specification of Equations
MPS	Examine the influence of monetary policy actions on economic activity.	1. Extensive disaggregation of the monetary sector. 2. Jorgenson-Bischoff investment functions. 3. Endogenous state and local government expenditures. 4. Extensive use of nonlinear specifications, intercept shifts, and first-order autoregressive corrections. 5. Alternative specifications of various equations.
Wharton (old)	To build a structural model based on the Keynesian theory of income determination, supplemented by wage-price adjustment equations and put it into practical use for short-run forecasting and policy simulation analysis.	1. Production functions are Cobb-Douglas type. 2. Investment functions have fixed distributed lag weights. 3. Nonlinear relationships are introduced between the unemployment rate and the money wage adjustment. 4. Direct estimation of the capacity utilization endogenously.
Wharton Mark III	To improve the earlier Wharton Model by: 1. Rework inventory theory. 2. Expand monetary sector. 3. More detailed treatment of government sector. 4. More detailed treatment of prices.	1. Extensive analysis of lag distributions in investment and other areas. 2. Introduction of an output decision function, and derivation of inventories residually. 3. Labor demand and price-wage behavior similar to Brookings.
Liu-Hwa	Forecasting and policy analysis.	1. Monthly data for GNP and its components generated. 2. Most stochastic equations diagonally recursive. 3. Liquid assets in 3 consumption equations. 4. Interest rates present but weak in business investment equations. 5. CES production function.

References

[1] AGRAWALA, R., AND J. DRINKWATER, "Consumption Functions with Shifting Parameters Due to Socio-economic Factors," *Rev. Econ. & Stat.* 54:89–96, Feb. 1972.

[2] AIGNER, DENNIS J., "A Compendium on Estimation of the Auto-regressive-Moving Average Model from Time-Series Data," *Internat. Econ. Rev.* 12:348–371, Oct. 1971.

[3] ANDERSEN, L. C., AND K. C. CARLSON, "A Monetarist Model for Economic Stabilization," *Federal Reserve Bank of St. Louis Rev.* 52:7–25, Nov. 1970.

[4] BAUMOL, WILLIAM J., *Economic Theory and Operations Analysis*, 2nd ed., Englewood Cliffs, N. J., Prentice-Hall, Inc., 1965.

[5] BERGMANN, BARBARA R., "Combining Microsimulation and Regression: A 'Prepared' Regression of Poverty Incidence on Unemployment and Growth," to be published in *Econometrica*.

[6] BRUNDY, J. M., AND D. W. JORGENSON, "Efficient Estimation of Simultaneous Equations by Instrumental Variables," *Rev. Econ. & Stat.* 53:207–224, Aug. 1971.

[7] CHILDS, GERALD L., *Unfilled Orders and Inventories: A Structural Analysis*, Amsterdam, North-Holland Publishing Co., 1967.

[8] CHRIST, CARL, *Econometric Models and Methods*, New York, John Wiley & Sons, Inc., 1966.

[9] COLE, ROSANNE, "Data Errors and Forecasting Accuracy," in *Economic Forecasts and Expectations: Analysis of Forecasting Behavior and Performance*, ed. Jacob Mincer, New York, National Bureau of Economic Research, 1969.

[10] DHRYMES, PHOEBUS J., *et al.*, "Criteria for Evaluation of Econometric Models," *Annals of Econ. & Social Measurement* 1:291–324, July 1972.

[11] DUESENBERRY, J. S., O. ECKSTEIN, AND G. FROMM, "A Simulation of the United States Economy in Recession," *Econometrica* 28:749–809, Oct. 1960.

[12] ECKSTEIN, O., AND G. FROMM, "The Price Equation," *Am. Econ. Rev.* 58:1159–1184, Dec. 1968.

[13] ECKSTEIN, O., *et al.*, *The Data Resources Econometric Forecasting System: A Preliminary Account*, Dec. 1971.

[14] EDGERTON, DAVID L., "Some Properties of Two Stage Least Squares as Applied to Nonlinear Models," *Internat. Econ. Rev.* 13:26–32, Feb. 1972.

[15] EISNER, ROBERT, AND R. STROTZ, "Determinants of Business Investment," in *Impacts of Monetary Policy*, Commission on Money and Credit, Englewood Cliffs, N. J., Prentice-Hall, Inc., 1963, pp. 59–337.

[16] ELLIOTT, WALTER J., "Forecasting and Analysis of Corporate Financial Performance with an Econometric Model of the Firm," paper presented at the meeting of the Western Finance Association, 1971.

[17] EVANS, M. K., AND L. R. KLEIN, *The Wharton Econometric Forecasting Model*, Studies in Quantitative Economics 2, Philadelphia, Wharton School of Finance and Commerce, 1967.

[18] FAIR, RAY C., *A Short-run Forecasting Model of the United States Economy*, Lexington, Mass., D. C. Heath, 1971.

[19] ———, "A Comparison of Alternative Estimators of Macroeconomic Models," Econometric Res. Prog. Res. Memorandum 121, Princeton University, Sept. 1971.

[20] ———, "Efficient Estimation of Simultaneous Equations with Auto-regressive Errors by Instrumental Variables," *Rev. Econ. & Stat.* 44:444–449, Nov. 1972.

[21] Fisher, F. M., P. H. Cootner, and M. N. Baily, "An Econometric Model of the World Copper Industry," *Bell J. of Econ. & Management Science* 3:568–609, Autumn 1972.

[22] Forrester, Jay W., *Industrial Dynamics*, Cambridge, Mass., Massachusetts Institute of Technology, 1961.

[23] Friedman, Benjamin M., "Optimal Economic Stabilization Policy: An Extended Framework," *J. Pol. Econ.* 80:1002–1022, Sept./Oct. 1972.

[24] Friedman, Milton, *Essays in Positive Economics*, Chicago, University of Chicago Press, 1953.

[25] ———, *A Theory of the Consumption Function*, New York, National Bureau of Economic Research, 1959.

[26] ———, and Walter W. Heller, *Monetary versus Fiscal Policy*, New York, Norton, 1969.

[27] Fromm, Gary, "Survey of U. S. Models," paper presented at the conference on *The Brookings Model: Perspective and Recent Developments*, Washington, D. C., Feb. 1972.

[28] ———, and George Schink, "Aggregation and Econometric Models," to be published in *Internat. Econ. Rev.*

[29] ———, and Paul Taubman, *Policy Simulations with an Econometric Model*, Washington, D. C., The Brookings Institution, 1968.

[30] ———, and Lawrence R. Klein, "A Comparison of Eleven Econometric Models of the United States," paper presented at meetings of the American Economic Association, Toronto, Dec. 1972.

[31] Goldberger, Arthur S., *Topics in Regression Analysis*, New York, Macmillan & Co., 1968.

[32] Goldfeld, S. M., and R. Quandt, "Nonlinear Simultaneous Equations: Estimation and Predictions," *Internat. Econ. Rev.* 9:113–117, Feb. 1968.

[33] Griliches, Zvi, "Distributed Lags: A Survey," *Econometrica* 35:16–49, Jan. 1967.

[34] Haitovsky, Yoel, and George Treyz, "Forecasts with Quarterly Econometric Models: Equation Adjustments and Benchmark Predictions: The U. S. Experience," *Rev. Econ. & Stat.* 44:317–325, Aug. 1972.

[35] Hay, George A., "The Dynamics of Firm Behavior under Alternative Cost Structures," *Am. Econ. Rev.* 62:403–413, June 1972.

[36] Holt, C. C., F. Modigliani, J. F. Muth, and H. A. Simon, *Planning, Production, Inventories and Work Force*, Englewood Cliffs, N. J., Prentice-Hall, Inc., 1960.

[37] Houthakker, H. S., and Lester, D. Taylor, *Consumer Demand in the United States*, 2nd ed., Cambridge, Mass., 1970.

[38] Hymans, Saul H., and Harold T. Shapiro, *The DHL III Quarterly Econometric Model of the U. S. Economy*, Research Seminar in Quantitative Economics, University of Michigan, 1970.

[39] ———, "Prices and Price Behavior in Three U. S. Econometric Models," in *The Econometrics of Price Determination*, ed. O. Eckstein, Washington, D. C., Federal Reserve System, 1972, pp. 309–324.

[40] Johnston, J., *Econometric Methods*, 2nd ed., New York, McGraw-Hill, Inc., 1972.

[41] Jorgenson, D. W., "Anticipations and Investment Behavior," in *The Brookings Quarterly Econometric Model of the United States*, eds, J. S. Duesenberry, G. Fromm, L. R. Klein, and E. Kuh, Chicago, Rand McNally, 1965, pp. 35–92.

[42] ———, "Econometric Studies of Investment Behavior: A Survey," *J. Econ. Lit.* 9:1111–1147, Dec. 1971.

[43] ———, "Investment Behavior and the Production Function," in *Bell J. of Econ. & Management Science* 3:220–251, Spring 1972.

[44] Juster, F. Thomas, and Paul Wachtel, "Anticipatory and Objective Models of Durable Goods Demand," *Am. Econ. Rev.* 62:564–579, Sept. 1972.

[45] Kelejian, Harry H., "Two-Stage Least Squares and Economic Systems Linear in Parameters but Nonlinear in Endogenous Variables," *J. Am. Stat. Assoc.* 66:373–374, June 1971.

[46] Klein, Lawrence R., "Forecasting and Policy Evaluation Using Large Scale Econometric Models: The State of the Art," in *Frontiers in Quantitative Economics*, ed. M. D. Intriligator, Amsterdam, North-Holland Publishing Co., 1970.

[47] ———, ed., *Essays in Industrial Econometrics*, I, II, III, Studies in Quantitative Economics 3, 4, 5, Philadelphia, Wharton School of Finance and Commerce, 1968–71.

[48] ———, and H. Rubin, "A Constant Utility Index of the Cost of Living," *Rev. Econ. Stud.* 15:84–87, 1947.

[49] Koopmans, Tjalling, *Three Essays in the State of Economic Science*, New York, McGraw-Hill, Inc., 1957.

[50] Liebenberg, M., G. Green, A. Hirsch, "The Office of Business Economics 1970 Quarterly Econometric Model," U. S. Dept. of Commerce, Econometrics Branch, March 1971.

[51] Liu, T. C., "An Exploratory Quarterly Econometric Model of Effective Demand in the Postwar U. S. Economy," *Econometrica* 31:301–348, July 1963.

[52] ———, "Underidentification, Structural Estimation, and Forecasting," *Econometrica* 28:855–865, Oct. 1960.

[53] ———, and E. C. Hwa, "Equations, Forecasts and Features of a Monthly Econometric Model of the U. S.: Preliminary Version," unpublished manuscript, Nov. 1972.

[54] Maddala, G. S., and A. S. Rao, "Maximum Likelihood Estimation of Solow's and Jorgenson's Distributed Lag Models," *Rev. Econ. & Stat.* 53:80–88, Feb. 1971.

[55] McCarthy, Michael D., *The Wharton Quarterly Econometric Forecasting Model: Mark III*, Studies in Quantitative Economics 6, Philadelphia, Wharton School of Finance and Commerce, 1972.

[56] Mitchell, Bridger M., "Estimation of Large Econometric Models by Principal Components and Instrumental Variable Methods," *Rev. Econ. & Stat.* 53:140–146, May 1971.

[57] Morgenstern, Oskar, *On the Accuracy of Economic Observations*, Princeton, N. J., Princeton University Press, 1963.

[58] Naylor, Thomas H., W. H. Wallace, and W. E. Sasser, "A Computer Simulation of the Textile Industry," *J. Am. Stat. Assoc.* 62:1338–1364, Dec. 1967.

[59] Naylor, Thomas H., "Corporate Simulation Models and the Economic Theory of the Firm," in *Corporate Simulation Models*, ed. Albert N. Schreiber, Seattle, University of Washington, 1970.

[60] Nordhaus, William D., "Recent Developments in

Price Dynamics," in *The Econometrics of Price Determination*, ed. O. Eckstein, Washington, D. C., Federal Reserve System, 1972, pp. 16–49.

[61] ORCUTT, G. H., M. GREENBERGER, J. KORBEL, AND A. RIVLIN, *Microanalysis of Socioeconomic Systems: A Simulation Study*, New York, Harper & Bros., 1961.

[62] PHLIPS, LOUIS, "A Dynamic Version of the Linear Expenditure Model," *Rev. Econ. & Stat.* 54:450–458, Nov. 1972.

[63] POLLAK, ROBERT A., "Habit Formation and Dynamic Demand Functions," *J. Pol. Econ.* 78:745–763, July/Aug. 1970.

[64] ROBBINS, LIONEL W., *An Essay on the Nature & Significance of Economic Science*, rev. ed., London, Macmillan & Co., 1949.

[65] SAMUELSON, PAUL A., "Maximum Principles in Analytical Economics," *Am. Econ. Rev.* 62:249–262, June 1972.

[66] SCHRIEBER, ALBERT N., *Corporate Simulation Models*, Seattle, University of Washington, 1970.

[67] STONE, RICHARD, "Linear Expenditure Systems and Demand Analysis: An Application to the Pattern of British Demand," *Econ. J.* 64:511–527, 1954.

[68] TAUBMAN, PAUL, "The Consumption Function for Short-run Models," paper presented at the conference on *The Brookings Model: Perspective and Recent Developments*, Washington, D. C., Feb. 1972.

[69] TAYLOR, LESTER D., AND DANIEL WEISERBS, "On the Estimation of Dynamic Demand Functions," *Rev. Econ. & Stat.* 54:459–465, Nov. 1972.

[70] THEIL, HENRI, *Linear Aggregation of Economic Relations*, Amsterdam, North-Holland Publishing Co., 1954.

[71] ———, *Optimal Decision Rules for Government and Industry*, Amsterdam, North-Holland Publishing Co., 1964.

[72] TREYZ, GEORGE, "An Econometric Procedure for Ex Post Policy Evaluation," *Internat. Econ. Rev.* 13:212–222, June 1972.

Discussion: CARL F. CHRIST, *The Johns Hopkins University*

It is a pleasure to discuss Prof. Shapiro's interesting and illuminating paper. I should like to begin with a brief summary of his main points.

He defines an empirical theory as a theory that is capable of being refuted by experience even though it may be logically consistent. He comes to the conclusion that it is impossible to establish either the truth or the falsity of any empirical theory or model. Hence he devotes the remainder of his paper to the evaluation of econometric models in the light of their purposes. In most cases the purpose is the prediction of the future course of economic events. Therefore, evaluation of econometric models consists chiefly in the testing of the predictions that they make. He distinguishes two broad types of tests, dealing respectively with forecasts of events occurring within the sample period that was used for estimation and with forecasts of events occurring after the end of the sample period. The within sample forecasts he discusses are based upon the now familiar simulation technique, which takes as given the initial presample values of all endogenous variables, and the values of all exogenous variables during the sample, and computes year by year from the model the values of the endogenous variables, by using the previously computed endogenous varibles whenever lagged endogenous values are needed for a subsequent period. He correctly advocates the use of stochastic simulation rather than exact simulation, by using a randomly generated disturbance in each equation for each period. One can of course distinguish two types of post-sample forecasts, namely, unconditional forecasts in which the forecaster must forecast post-sample exogenous variables in order to compute his post-sample forecasts of the endogenous variables, and conditional forecasts (conditional upon the correct values of the post-sample exogenous variables). Prof. Shapiro concludes with a brief (and, considering its brevity, a remarkably thorough and informative) discussion of available and possible techniques for testing forecasts, including nonparametric measures of forecasting ability.

I agree that it is impossible to establish the truth of any empirical theory or model. A great physics teacher, Eric Rogers of Princeton, explained this by saying, "You can never prove your neighbor perpetually honest, you can at best fail to prove him dishonest." However, I disagree that it is impossible to prove the falsity of any empirical theory or model. It is easy to give counter examples in economics. I offer three. The very crude quantity theory of money asserts that the ratio of the price level to the money stock is a constant. This has been refuted for many countries in many periods. The simplest Keynesian nonstochastic consumption equation says that consumption expenditure in any year is an exact linear function of disposable income in that year. This has been refuted. The simple acceleration principle says that investment in any year is proportional to the change of consumer expenditure since the preceding year. This, too, has been refuted. Now if we consider stochastic empirical theories, rather than all empirical theories, I come around to a position of partial agreement with Prof. Shapiro concerning the impossibility of establishing the falsity of empirical theories. The point is that with a stochastic model one can make a type I error, that is, one can incorrectly reject a true theory, and with samples of finite size there is no way to reduce the probability of this type of error to zero without at the same time foregoing the possibility of rejecting the theory at all.

An important characteristic of econometric models is that they are approximations to reality. They can never hope to be as exact as are physical theories of particle motion or electromagnetic radiation, theories of chemical reactions, or theories of the genetic code. Therefore Prof. Shapiro is correct that we should not be concerned with the attempt to show that econometric models are true or false. Rather we should test them to discover the extent to which they are useful for purposes for which they are intended.

Prof. Shapiro concentrates on prediction of future economic events as a major purpose of econometric models. There are other purposes, such as the simple quest for understanding or for knowledge of what difference it would have made to have taken a different policy action. But predictive ability is essential for these purposes also, for a theory that cannot predict cannot be confidently accepted as a guide to those questions.

To pass the predictive test satisfactorily, a theory must be able to predict events whose occurrence was not known to the builder of the theory at the time he built it. The surest way to provide for this is to test the theory's predictions of events that had not yet occurred when the theory was constructed. It has sometimes been suggested that a body of data be divided into two parts, one part to be used to construct the theory and estimate the parameters of its relationships, and the other part to be saved and used for testing. This approach is not satisfactory, because model builders know too much about economic events that have already occurred to be able to construct models as if in ignorance of part of the available data.

It is useful to distinguish four kinds of predictions that econometric models can make of events that occur after the model is constructed. The first is usually called *ex post* prediction and refers to predictions based on values of exogenous variables that are correct. Such predictions cannot be made until after the period to which they apply because they cannot be made until the correct values of the exogenous variables have been observed. Such predictions provide a test of the econometric model, apart from the ability of the predictor to predict the values of the exogenous variables.

The other three types of prediction are usually called *ex ante* prediction because they are made before the occurrence of the events to be predicted and hence require the predictor to predict values of the exogenous variables. One way to make such *ex ante* predictions is to make no adjustments whatever to the estimated equations of the econometric model. A second way is to make adjustments based on some automatic formula specified in advance, such as adding the preceding period's prediction error for each variable to the prediction made by the model for the current period. The third way is by making subjective adjustments to the predictions that are made by the econometric model, using economic judgment rather than an automatic rule that is spelled out in advance. For example, if the model makes a forecast of unemployment that seems implausibly high to the economist, he may reduce the model's forecast by a subjectively chosen amount. All three types of *ex ante* forecasting can go wrong if predictions of the exogenous variables are not correct, and therefore they are not pure tests of the econometric model alone but are tests of a mixture of the model itself and the economist's ability to forecast exogenous variables. Should subjective adjustments be applied to *ex ante* predictions made by econometric models? The answer depends upon the purpose of the exercise. If the purpose is to plan actions whose consequences will have to be borne by those who take the actions, then subjective adjustments are virtually inevitable, for few decision-makers believe so strongly in their econometric models that they will accept whatever predictions those models generate. If the purpose is the evaluation of a scientific tool for forecasting, then I side with Prof. Ray Fair of Princeton and insist that subjective adjustments not be made.

In connection with the testing of predictions made *ex post* and *ex ante*, with and without adjustments, I would like to commend to your attention the two-volume proceedings of a

National Bureau of Economic Research conference held in 1969 entitled, *Econometric Models of Cyclical Behavior*, edited by Bert G. Hickman, and published by the National Bureau of Economic Research in 1972.

I would like to see aggregate econometric models' predictions tested in the following ways.

Forecasting errors, including simulation errors during the sample period, should be computed for several important endogenous variables, not simply for forecasts one quarter ahead, but for forecasts two, three and four quarters ahead, and possibly further. They should be computed for several types of forecasts, including forecasts within the sample based on simulations using correct exogenous variables, forecasts after the end of the sample period using correct exogenous variables both without adjustment of the model and with whatever automatic adjustment rule the proponents of the model would suggest, and *ex ante* forecasts made with no adjustment of the model, with an automatic adjustment proposed by the model builder, and with subjective adjustments used by the forecaster. Forecasts should be made using preliminary data, such as are available at or soon after the end of the period in question, and also for revised data such as become available only several months or years after the period in question. This comparison is particularly interesting, inasmuch as Professors Franco Modigliani and Albert Ando have said that their version of the FRB-Penn-MIT model does a better job of forecasting the revised GNP data than it does of forecasting the preliminary data that are first published, and they conclude that the preliminary data are incorrect. Forecasts also should be compared when the parameters of the model are frequently reestimated, as against when the model is allowed to make forecasts for several years without reestimation of its parameters.

Residuals should be computed for all structural equations in the model, in order that it can be seen which structural equations conform to the data and which do not. This should be done both for within-sample data and for data after the end of the sample. Structural equations that perform badly can then be candidates for research and revision.

Forecasts made by econometric models should be compared with those made by naive models and with those made by forecasters who use general judgment and economic knowledge rather than models. Accuracy of forecasts of econometric models should be compared with the degree of accuracy that is required in order that forecasts be useful for economic policy.

Discussion: GORDON C. RAUSSER, *The University of Chicago**

Professors Fromm and Shapiro have each presented an interesting paper. Given the nature of their papers, a more appropriate title for the session might be "The Validity and Verification of Large-Scale Econometric Models," or still more appropriately "Does the Search for Quantitative Economic Knowledge Remain an Essay in Persuasion?" I shall return to the search for economic knowledge at a later point in my comments. In the meantime, it is revealing to note the dissimilarities between the two papers with respect to methodological foundations. Professor Shapiro (S) treats in some detail one philosophical position while Professor Fromm (F) informs us that excursions into the nature of economic science are largely barren. Furthermore, S is not concerned with the development of a new theory although he does point out that we are never justified in inferring theories from empirical observations (Hume's problem of induction). This suggests that the last section of F's paper (on the movement from empirical models to modifications or improvements of theory) is superfluous. F proceeds cautiously in this regard and unfortunately fails to provide any (of the available) historical examples in economics of reductive or for that matter inductive inference. In this same section, F speaks loosely of verification while S points out that verification is not possible; only *corroboration* is possible.

S states that there *seems* to be no general agreement among economists on the meaning and purpose of model verification. An examination of the methodological positions advanced by Robbins, Friedman, Koopmans (all referenced in F), and Samuelson [20] as well as other economists clearly suggests that we can attach a high degree of corroboration to this statement. This is not surprising given the substantial disagreement among philosophers (to whom the above methodological positions can be traced) on matters of "validity," "truth," "reality," and thus model verification. However, S's oral presentation suggests that he is of the opinion that this latter disagreement either does not exist or that it is unimportant. His discussion on verification in the empirical sciences emanates almost entirely from the work of a single philosopher, *viz.*, Popper [17]. There is, I submit, a number of useful concepts introduced by other philosophers (cf. [3, 7, 8, 11, 12, 13, 19] among others) which substantiate some and refute other elements of S's (or Popper's) views. These concepts assist us in understanding the process of model specification, estimation, selection, and evaluation. In what follows I shall restrict my remarks on such concepts and other topics of interest in the presented papers to three arbitrarily designated categories: paradigms and economic theory; model specification, estimation, and evaluation; and an alternative approach to model construction and evaluation.

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Paradigms and Economic Theory

The application of Kuhn's [13] notion of a paradigm to economics is becoming increasingly fashionable.[1] In the present context, it is useful to note that a paradigm typically defines a large set of possible hypotheses and makes no claims for the validity of any particular member of that set. Paradigms, unlike the hypotheses to which they give rise, cannot be validated by experimental or statistical methods.[2] For example, the maximum principle discussed by F is not a hypothesis but a paradigm; and although a specific hypothesis embodying some version of the maximum principle can, in effect, be tested, the maximum principle paradigm cannot.[3] This does not suggest that the maximum principle ought to be abandoned. On the contrary, since abstractions from details are essential, any usable model must be a misspecification of the system to which it refers. We have no option but to construct models which fall short of a complete specification of the system under examination. In this sense all model representations, econometric or otherwise, are partially reduced forms (due to omission of variables, distortion of relationships, aggregation, etc.) even though we frequently refer to them as structural models. It is always possible to imagine a more fundamental explanation of the phenomenon under examination involving more equations and thus endogenous variables. Hence it appears reasonable to suggest that (a) economic models cannot be judged solely by the resemblance between their specification and the systems which they are designed to represent, and (b) the choice of different model specifications of the same system by different economists implies no presumption that one of them must be in error. For these reasons, it is safer to investigate the "sufficiency" of models rather than their "realism," i.e., is the constructed model, for the purposes designed, adequately sufficient.[4]

S suggests but fails to mention explicitly that the requisite conditions for any particular theoretical formulation are never likely to be met and thus they should be no more than a subsidiary concern. The important issue is how extensively such conditions can be violated without seriously impugning the results obtained. Few would attempt to argue that Marshall's static equilibrium formulation or for that matter Jorgenson's investment theory[5] is internally consistent; however, some would contend that such theories are reasonably accurate and useful depending, of course, upon the purposes of the analysis.

S's reference to the impossibility of falsifying any empirical theory on the basis of observation is far more reasonable if couched specifically in terms of paradigms and not testable hypotheses (whether of the nested or non-nested type). Various paradigms of microeconomic theory (e.g., perfect competition, imperfect competition, organizational behavior of the Cyert and March [4] type) or of macroeconomic theory (e.g., neoclassical, neoKeynesian) are not directly confronted with empirical evidence.

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[1] A paradigm, in the natural sciences as well as in economics, defines the type of relationships to be investigated and the methods and abstractions which are regarded as legitimate within a particular problem area.

[2] Some of the members may be mutually exclusive alternatives.

[3] For example, the conditions under which the firm profit-maximization formulation of the maximum principle is unique, *viz.*, the conditions of long-run static equilibrium and perfect knowledge, are never likely to be met.

[4] On this score, the Liu criticism referenced by F is misplaced as Fisher [5] has shown via some proximity theorems.

[5] It is interesting to note that Nerlove [16, p. 223] has recently characterized Jorgenson's formulation "... as a perfect paradigm of the ad hoc superposition of a lag structure on what is an essentially static theory and the resulting difficulties in the interpretation of empirical lag structures."

Although some would argue otherwise, a disregard for empirical evidence is generally appropriate for conflicting paradigms; in a conflict of paradigms the disagreement does not center on specific hypotheses but about the types of hypotheses and the type of data that might be presented for empirical investigation. Furthermore, it is difficult if not impossible to isolate criteria for judging among paradigms that are not products of the paradigms themselves.[6] F's reference to the qualification to neoclassical optimization theory offered by Baumol simply represents an alternative paradigm. The impact of this alternative paradigm (especially in the context of its extensions [4]) has not been substantial. I suspect that this is partly the result of the dominance of market paradigms which have conditioned most economists to view the firm as a basic element rather than as an economic system worthy of investigation.[7]

S's argument might also have been more convincing if he had noted the usual distinction between experimental and nonexperimental empirical sciences. To be sure, since economics must typically operate in an "open system" where noncontrollable factors can always interfere with the operation of economic forces, economists can never be certain that the requisite conditions necessary to examine their hypotheses actually obtain. Moreover, as economic systems may not be explicable as a simple, or even a weighted, sum of separate effects, it is the contrast (especially for the types of models surveyed by F), not the comparison, between economics and the experimental sciences which is illuminating. Kuhn's analysis which is directed chiefly to the physical sciences requires some modification when applied to the special case of economics and other social sciences. For the latter sciences it is not surprising that a paradigm, once established, is especially difficult to overthrow. As its continued usefulness depends not only on the existence of unsolved problems but also on the prospects of their eventual solution by its application, there is no unequivocal standard by which it, the paradigm, can be refuted. This is reflected by the Gurley [9] and Solow [21] discussions in a recent proceedings issue of the *American Economic Review*. Their discussions also reflect Kuhn's notion that the conflict among paradigms depends not only on their relative success, however measured, in explaining certain phenomena but also on judgments about which phenomena ought to be explained.

From the standpoint of the model builder, the relationship among a paradigm (P), maintained hypotheses (Ω), and testable hypotheses (ω) might be simply characterized as $\omega \in \Omega \in P$. That is, the paradigm defines a set of possible maintained hypotheses, and the selected maintained hypotheses in turn isolate a still smaller set which represents the testable hypotheses. In this setting the model builder in a sense becomes a prisoner not only of the maintained hypotheses but also of the paradigm with which he operates. Nevertheless, to glean some information from a particular body of data, a paradigm is needed as are maintained hypotheses involving in most cases arbitrary judgments with respect to forms of functional relationships, nature of lag distributions, and the like. An important part of the art of empirical econometrics is knowing how much to include in the maintained hypotheses or model specification; the use of intuition, logic, and the "pragmatic test of validity" are often necessary to restrict the range of possible specifications.[8] Some elements of the maintained hypothesis may, of course, be inconsistent with the parent population generating the observed sample observations. To ascertain potential inconsistencies, we have no recourse but to relax and test certain presumed crucial maintained hypotheses. This is perhaps the only objective grounds for preferring one set of maintained hypotheses over some other set, assuming both are equally reasonable from a theoretical, intuitive, and/or technical standpoint.[9] All of this typically takes place within the context of a particular paradigm. Except perhaps for the case in which an alternative or new paradigm is, as Kuhn [13, p. 95] notes, "simply a higher level theory than those known before, one that linked together a whole group of lower level theories without substantially changing any," the possibility of relaxing maintained elements of one paradigm and moving into another is remote.

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[6] The apparently so objective notion of rationality is in fact very heavily paradigm-dependent.

[7] As Kuhn [13] suggests, if criteria employed in an existing paradigm are used in judging between it and a new paradigm, the latter will typically perform rather badly.

[8] Clearly, if too much is assumed, there may be little or nothing left to test, while if too little is assumed, it may not be possible to reach any conclusion or else the analysis may become hopelessly complex.

[9] The chief difficulty is that there are in principle an infinite number of hypotheses capable of explaining a given finite body of data.

For the lower-level or testable hypotheses[10] which treat Ω and P as given and even elements of Ω which are relaxed, S's argument on the impossibility of falsification is a bit too strong. In a probabilistic sense, there is of course a type I error associated with rejecting a true hypothesis; nevertheless, for many testable hypotheses which come to mind, the associated type I errors are so small that they can be rejected with little loss, regardless of model purpose.

Turning more specifically to S's representation of Popper, the latter's views on inductive logic (infinite regress or a priorism), deductive logic, testability criteria (simplicity), demarcation criteria (between science and metaphysical speculation), and falsification (his major emphasis), though influential, have not won universal acceptance. In a probabilistic context the "problem of induction" loses much of its relevance. I. J. Good has gone so far as to argue that Popper's view destroys not only scientific induction but science itself. The formal basis for this statement and some of the major arguments against Popper's philosophy of induction may be found in Good [7].

In Jeffreys' [11, 12] view deductive logic is simply encompassed within inductive logic. Hence, Jeffreys' rules of inductive inference contain many elements of Popper's deductive approach, with the latter offering special limiting cases of statement forms obtained by the use of inductive logic. The implications of these rules for Bayesian analysis have been illustrated in many places. However, what is not generally recognized is that there are several formal analogies between Popper's degree of corroboration and Bayes' theorem on probability [8]. To be sure, there are costs as well as benefits associated with the Jeffreys' approach. The costs are concerned with *inter alia*, the difficulty of characterizing appropriate initial or prior probability distributions, the vague process of generalization, metaphysical problems, and the potential effects on the accumulation of empirical knowledge. Nevertheless, within the confines of a particular paradigm, the process of revising probabilities associated with propositions as new information evolves is the essense of learning from experience. This process is formalized and made operational by Bayes' theorem.

The model purpose argument of theory offered by S, i.e., scientists do not construct theories for the "fun of it," requires substantial qualification in the case of economics as the recent presidential address of Leontief [15] as well as Hahn [10] would suggest. S goes on to equate purpose almost entirely with prediction and in the process comes dangerously close to Friedman's methodological position but deviates from Popper's. Here it may have been useful if S distinguished more explicitly among as well as noted the nonmutually exclusive nature of models constructed for explanation, prediction, and decision purposes. Models which are to be utilized for decision purposes obviously require either explicitly or implicitly a criterion function for the policy makers (which represents an ordering for the states of the economy under examination) while models constructed strictly for prediction purposes do not require such information. Worland [24] has recently argued that it is possible to refute economic theory or paradigms only in a decision context, i.e., a theoretical anomaly in the Kuhn sense is not possible in a science such as economics; only a policy anomaly leading to the rejection of one paradigm and the replacement by another is possible.

In addition to the obvious temporal asymmetry between explanation and prediction [19], complex systems models often require several distinct theories in order to predict the behavior of related empirical phenomena. In the latter instance, as noted in [2], the distinction between the objectives of explanation and prediction can be most meaningful. As most philosophers would agree, satisfactory prediction can take place without satisfactory explanation. From a logical point of view, however, if the "validity" or the corroboration of its prediction statements is the sole measure of a theory, falsification is clearly rendered impossible. For this reason, Popper would object to treating theory as nothing but an instrument for generating prediction statements. He regards the explanation of observable phenomena as crucial in the development of higher-level hypotheses.

Given the above background, the differences between Popper and Kuhn become more distinct. Kuhn does not emphasize falsification as a crucial element in scientific progress and finds no support for Popper's idealization of science—falsifying instances seldom lead to the revocation of theory. A paradigm is adhered to until a superior alternative appears to supplant it. In a conflict among paradigms, however, the "validity of assumptions" is a legitimate criterion, and thus Kuhn's view is not consistent with Friedman's position. Popper places his entire emphasis on falsification (at least in principle) and fails to recognize the costs involved in renouncing a predictively useful theory for which there is no adequate replacement.

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[10] For a discussion on hierarchy among hypotheses, see Braithwaite [3].

Model Specification, Estimation and Evaluation

The operational recognition of the paradigm notion in the context of model specification, estimation, and evaluation is more fully explored in [18]. In the construction of models, the possibility of avoiding much general confusion and positive dogmatism by use of this notion appears to be illuminating. Moreover, the employment of *a priori* information, the examination of internal consistencies (i.e., the evaluation of dynamic multiples, cycle lengths, stability conditions, etc.), the transfer of qualitative restrictions derived from microeconomic theory to macroeconomic relationships, and the introduction of dynamic behavior through the back door all assume a new perspective. On each of these counts the models surveyed by F can be severely criticized. Space limitations preclude a more complete discussion of the relation between these nontrivial matters and the construction of large scale systems models. Thus I will simply refer those who might be interested to the above referenced paper and note a few comments or queries which relate mainly to S's paper and are also treated at some length in [18]. As will become obvious to those who have read Dhrymes, *et al.* (referenced in both S and F and hereafter referred to as MAA), some of the comments advanced extend beyond S's paper to MAA. This seems justifiable for a number of reasons, the least important of which is that S's discussion on evaluation is virtually identical to the MAA treatment on nonparametric evaluation.

First, with respect to model specification, selection and estimation: (1) Particularly if a model is constructed for decision purposes, the method of estimation should (and not *may*) be a function of model purpose. (2) Recognizing that sample data are typically employed to assist in model specification, loss due to incorrect decisions, and thus the mean squared error or risk measures for gauging estimator performance, should not Stein-like estimators be utilized rather than conventional estimation methods? This is a problem which is neglected by MAA but has recently been investigated by G. Judge, T. D. Wallace, and others. Along these same lines, as suggested in [14], more econometric research effort might "best" be devoted to developing statistical procedures for drawing inferences based on false models. (3) Given the evidence on the structural instability of available econometric models, even noting all the qualifications that have been made (see reference [17] in S's paper), doesn't it seem prudent to allow explicitly for the possibility of maintained hypothesis as well as parameter revisions as new information evolves? In such a framework, limited memory filters and Bayesian methods would be particularly useful. Moreover, such a framework would provide a basis for formalizing S's argument that model corroboration is a continuous process or even Popper's [17, p. 280] statement that the quest for "... scientific objectivity makes it inevitable that every scientific statement must remain *tentative forever.*"

Second, more specifically with respect to model evaluation: (1) Why is not S's reported list of nonparametric measures categorized at least by the general purposes of explanation, prediction, and decision? Recognizing, as he does, that evaluation is properly treated as a problem-dependent process, such a categorization would appear most useful. (2) Would not an "evaluation" of the evaluation measures listed (as well as MAA's suggestion of a standardized list of properties investigated thus far) be a valuable addition to the literature? Instead of repeating material already presented in MAA, perhaps S should have considered attempting to indicate the relative cost and benefits of the various measures by purpose and from the research investigator viewpoint. (3) Assuming a constructed model is to be utilized for decision purposes and since it is very unlikely that a unique or single valued criterion function can be obtained, what should be the role of policy maker(s) or model user(s) in the evaluation process? In this regard it seems that it is only possible to capture an objective function set (or welfare correspondence) which, of course, complicates but nevertheless provides a formal initial basis for the policy analysis. Such a set will also provide a vehicle for resolving the multiple response problem noted by S (4). The experimental design literature has advanced far beyond full factorial representations, and thus S would be well advised to qualify his view on the difficulties of applying these techniques. (5) The limitations of simulation outlined by S pertain only to restricted stochastic models (i.e., those in which only the stochastic nature of the disturbance terms are recognized). There are, however, a number of other limitations of these methods, especially for nonlinear models and examinations which recognize the estimated sampling distributions for the unknown parameters. In addition, S failed to note or refer the reader to the reasonably well-documented comparative advantages and disadvantages of the Naylor, *et al.* versus the Howrey (referenced by S) use of spectrum analytic techniques. (6) Both S and MAA might have considered or at least mentioned the problem of insuring that a simulation model behaves as the experimenter intends. The importance of this problem is indicated in [6] and [23]. (7) An indication of S's failure to consider explicitly the properties of his suggested measures is revealed by his reference to the Cohen and Cyert procedure. As convincingly demonstrated in [1], this procedure in the context of even linear and restricted stochastic models can lead to perverse results. (8) Since S only provides a list of evaluation measures, it is surprising that he did not include some other techniques such as factor analysis and multiple comparisons and even more surprising that he failed to recognize the connection between Popper's degree of corroboration and information theory, in particular entropy measures and information inaccuracy statistics [22, pp. 644–662].

An Alternative Approach to Model Construction and Evaluation

Again this topic is more fully explored in [18]. Motivation for an alternative approach is based on the revealing critique of Morgenstern (referenced by F), the constraining feature of data availability on model construction, the misspecified nature of economic models, the possibility of capturing only small sample estimates, the apparent existence of structural changes, and imperfect information on future environments. The approach is based on adaptive or dual control techniques and includes as specific dimensions model purpose, learning, and sequential design of experiments. It attempts to formalize the purchasing of information and the learning of probabilities; it recognizes that the accumulation of information or empirical knowledge ought to be treated in an "active" rather than a "passive" fashion, i.e., we ought to "make" our experiences; and it is one way, perhaps the most efficient, of dealing with surprises generated by nonlinear models. Such an approach, in principle, can accommodate alternative paradigms and their associated implications for information, revisions, and additional data collection within the context of research and development strategies (R and D). However, it slightly alters Kuhn's and particularly Braithwaite's [3] emphasis on the hierarchy among hypotheses and the inherent unobservability of theoretical entities by explicitly recognizing that the unobservable of today may well become the observable of tomorrow.

Although the analytical possibilities of this approach are limited, a number of approximate procedures are available. A major danger of the approach, especially if alternative paradigms are under examination, is that its inherent flexibility may lead to sloppy analysis. Nevertheless, the shift in emphasis from the conventional analysis represented in MAA, S, and F to a dual control, R and D strategy approach to model construction and corroboration is regarded as desirable. Furthermore, it is a means of distinguishing to a greater extent the search for quantitative economic knowledge from a sequence of essays in persuasion.

References

[1] AIGNER, D., "A Note on Verification of Computer Simulation Models," *Mgt. Sci.* 18:615–619, July 1972.

[2] BEAR, D. V. T., AND D. ORR, "Logic and Expediency in Economic Theory," *J. Pol. Econ.* 75:188–196, April 1967.

[3] BRAITHWAITE, R. V., *Scientific Explanation*, Cambridge, Cambridge University Press, 1953.

[4] CYERT, R. M., AND J. G. MARCH, *A Behavioral Theory of the Firm*, Englewood Cliffs, Prentice-Hall, 1963.

[5] FISHER, F. M., "On the Cost of Approximate Specification in Simultaneous Equation Estimation," *Econometrica* 29:139–170, April 1961.

[6] FISHMAN, G. S., AND P. J. KIVIAT, *Digital Computer Simulation: Statistical Considerations*, Rand Corp. RM-5540 PR, 1967.

[7] GOOD, I. J., "Review of K. R. Popper, 'The Logic of Scientific Discovery,' " *Math. Rev.* 21:1171–1173, Nov. 1960.

[8] ———, "Corroboration, Explanation, Evolving Probability, Simplicity and a Sharpened Razor," *British J. Phil. Sci.* 19:123–143, April 1968.

[9] GURLEY, J., "The State of Political Economics," *Am. Econ. Rev.* 71:53–62, May 1971.

[10] HAHN, F. H., "Some Adjustment Problems," *Econometrica* 38:1–17, Jan. 1970.

[11] JEFFREYS, H., *Theory of Probability*, 3rd ed., Oxford, Clarendon Press, 1971.

[12] ———, *Scientific Interference*, 2nd ed., Cambridge, Cambridge University Press, 1957.

[13] KUHN, T., *The Structure of Scientific Revolutions*, 2nd ed., Chicago, The University of Chicago Press, 1970.

[14] LEAMER, E., "False Models and Post Data Model Construction," unpublished paper, Harvard University, 1972.

[15] LEONTIEF, W., "Theoretical Assumptions and Nonobserved Facts," *Am. Econ. Rev.* 71:1–7, March 1971.

[16] NERLOVE, M., "On Lags in Economic Behavior," *Econometrica* 40:221–251, March 1972.

[17] POPPER, K. R., *The Logic of Scientific Discovery*, New York, Basic Books, 1959.

[18] RAUSSER, G. C., "Corroboration, Verification, and Validity of Econometric Models," unpublished paper, University of California-Davis, 1973.

[19] RESCHER, N., *Topics in Philosophical Logic*, Dordrecht, D. Reidel, 1968.

[20] SAMUELSON, P. A., "Problems of Methodology: Discussion," *Am. Econ. Rev.* 53:231–236, May 1963.

[21] SOLOW, R. M., "Discussion," *Am. Econ. Rev.* 71:63–65, May 1971.

[22] THEIL, HENRI, *Principles of Econometrics*, New York, John Wiley & Sons, 1971.

[23] VAN HORN, R. L., "Validation of Simulation Results," *Mgt. Sci.* 17:247–258, Jan. 1971.

[24] WORLAND, S. T., "Radical Political Economy as a 'Scientific Revolution'," *Southern Econ. J.* 39:274–284, Oct. 1972.

TRADE LIBERALIZATION IN AGRICULTURAL PRODUCTS

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Future Directions for U. S. Trade

C. Fred Bergsten

The Setting

The United States now faces a clear choice between alternative trade policies. On the one hand, the AFL-CIO and some others actively support unilateral U. S. imposition of a new regime of comprehensive import quotas. If erected in the form which these groups presently propose, the Burke-Hartke bill, the new regime would *reduce* U. S. imports by at least $11 billion from the 1971 level and limit their growth to a fixed share of U. S. consumption thereafter.[1] Any such cutback in U. S. imports would cut back U. S. exports by at least a like amount, in view of foreign income effects, overt retaliation, and emulation by other countries of the U. S. moves. Thus the decline in world trade would be roughly double the size of the U. S. action—about 8 percent of world trade in 1971.[2]

The Burke-Hartke bill is highly unlikely to become law in its present extreme form. But a new "orderly marketing" regime, which would limit future import growth to some given share of the U. S. market, implemented either by the U. S. or through the favored new technique of "voluntary export restraints" by foreign suppliers, is a distinct possibility.[3] Indeed, the U. S. has been applying such restraints in several key industries over the past decade (cotton textiles, meat, steel, synthetic and woolen textiles, stainless steel flatware, etc.), and such a generalized approach would in one sense represent a culmination of present trends.

On the other hand, the U. S. Administration and numerous private groups have been actively calling for new international negotiations to resume the earlier postwar effort to reduce national barriers to world trade, and to devise new international rules and mechanisms to govern those barriers which will continue to exist in the future. This approach is partly motivated by the traditional economic desire to eliminate foreign barriers to U. S. exports, and partly by the traditional foreign policy desire to use economic negotiations as a functional means for expanding global cooperation.

It is primarily motivated, however, by the realization that trade policy is dynamically unstable and that a theoretical third trade policy alternative—maintenance of the status quo—is untenable. Protectionist pleas by special interests can be countered only by trade liberalization in pursuit of the general interest. Steady movement toward trade liberalization is necessary to halt the acceleration of the trend toward increasing trade restrictions, and a new liberalizing initiative of sizable proportions might be required at this time in view of the strength of the protectionist pressures. If more proof of this eternal verity were needed, it is provided by the impressive success of U. S. special interests immediately after the completion of the Kennedy Round in obtaining new import protection (steel, meat, the pledge on synthetic and woolen textiles by both Presidential candidates in 1968 which culminated in new restraints in 1971) and altering the overall thrust of U. S. trade policy (severe tightening of the administration of antidumping and countervailing duty laws, the import surcharge of 1971, the near passage of the Mills bill in the face of Administration ambivalence in 1970).

Indeed, the primary impact of the Kennedy Round on world trade flows was not its tariff cuts. Its major achievement was in providing governments around the world with a broad international initiative of sufficient political importance to enable them to reject the en-

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[1] The bill also proposes severe new limitations on foreign direct investment by American firms. Though related to trade, and contributing to the protectionist trade pressures because they accelerate the pace of change occasioned by trade flows, foreign investment raises a host of different issues and will not be dealt with in this paper.

[2] The Burke-Hartke formula would of course produce a greater reduction of world trade in absolute terms from the levels which would have been reached by the time of its enactment, and the percentage decline would be larger as well because *all* growth beyond the 1965–69 base period for items brought under quota would be rolled back.

[3] For a complete analysis of the underlying economic and political changes which raise such a spectre, see Bergsten [1].

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treaties of particular domestic groups which sought trade restrictions that would have rendered its completion impossible. Again, the U. S. evidence is clear: demand for the restrictions which were implemented after 1967, as outlined above, grew rapidly during the 1960's despite steady growth of profits to record levels and steady decline of unemployment to post-Korea lows. They probably could not have been forestalled without the simultaneous presence of a major trade-liberalizing initiative, and they can certainly not be forestalled now with the far less satisfactory state of our domestic economy and external economic position.[4] It is even highly unlikely that individual industries can any longer be "bought off" by restrictions limited to them alone, in view of the political pressure for "equitable treatment" of all. Precisely this view motivated the "Byrnes basket" provision of the near-miss Mills bill of 1970, making eligible for import quotas all products where imports satisfied certain numerical criteria—a total of $7 billion of trade at that time.

In the absence of new trade liberalization, new trade restrictions are therefore likely in the United States. The implications for world agricultural trade are obvious. Farm trade attracts even more protectionism than industrial trade. It has firmly resisted the trade liberalization of the earlier postwar period, and was virtually untouched even by the Kennedy Round. It is thus clear that a major overall trade-liberalizing negotiation will be necessary to provide a framework for negotiation of any significant new liberalization of farm trade, since the U. S. could get major foreign concessions on agriculture only by extending concessions of its own in the industrial sector. (It is barely possible that the U. S. could get minor agricultural concessions in return for concessions on its own dairy imports, though the official position of the EC is that the dairy quotas are illegal under the GATT and thus the EC will pay nothing for their removal.) Further slippage away from liberal trade policies, whether through a discreet (or indiscreet) measure like the Burke-Hartke bill or through slippage into a policy vacuum, would probably lead to additional barriers to farm trade—at least in Europe, through new preferential deals on particular commodities and extension of the Common Agricultural Policy itself to additional products.[5] Johnson [5] points out the sharp differences for agriculture of these two potential trends in trade policy: under free trade, an increase of $5 billion in North American exports of grain and oilseeds alone, with much return of land to cultivation and highly favorable efforts on farm profits and jobs, in contrast to stagnant exports if there is no trade liberalization (and, I would add, probably some cutback if new restrictions were erected instead).[6]

The ultimate choice between the highly polarized alternatives could be very close, and I hazard no forecast of the outcome at this time. It seems that it will turn on five key issues, to be discussed below.

The Link to International Money

All theories of international trade which conclude that maximum freedom of trade maximizes world welfare rest on a variety of assumptions. One of these assumptions is the existence of equilibrium exchange rates. The absence of a monetary system which provides a mechanism for assuring equilibrium exchange rates thus severely jeopardizes the economic case for free trade. It certainly undermines political support for freer trade by eroding the competitive position of industries in countries with overvalued exchange rates and thereby generating additional desires for protection.[7] This is the real link between trade policy and international money.

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[4] Hence it is unfortunate that the EC, in the communique issued after its recent summit meeting, called for the next round of trade negotiations to be concluded by 1975. Aside from the impossibility of moving that fast, in view of the wide range and complexity of the issues involved, it would be undesirable to do so because the shield against new restrictions would then again be quickly dropped.

[5] Foreign retaliation against new U. S. import controls, or emulation thereof, might well hit U. S. agricultural exports, since protectionist forces in several key countries are strongest in agriculture and the U. S. has important comparative advantages in that sector. However, this would probably be a strategic error for the countries involved, assuming their goal was to get the U. S. to reverse its policy. This is because it would play directly into the hands of organized labor, cutting U. S. exports in a capital-intensive industry which is totally unorganized by the AFL-CIO and thus levying little offset on U. S. labor to their gains from restricting labor-intensive imports.

[6] It is possible, of course, that farm trade will continue to expand whether or not farm trade policy is liberalized (or even if new restrictions are implemented). This paper addresses only the policy issues and makes no effort to assess net developments in farm trade over the coming years.

[7] By stimulating excessive allocation of resources to export and import-competing industries in countries with undervalued rates, it also makes it harder for such countries to agree to revaluations—which would surrender their enhanced competitive positions.

Until recently, however, the U. S. has not sought an equilibrium exchange rate for the dollar. Indeed, the international monetary policy of the United States throughout the postwar period—until August 15, 1971—was aimed primarily at assuring financing for U. S. payments deficits, primarily through the key currency roles of the dollar. The adjustment mechanism in the dollar-centered monetary system was in fact biased against the United States, and the dollar actually appreciated against a weighted average of the other major currencies during the 1960's despite the persistence of U. S. payments deficits.[8]

Some observers argue that the dollar had become overvalued by the late 1950's. Others view the overvaluation as occasioned solely by the inflation associated with the Vietnam war. Whatever, the timing, however, it is clear that a fundamental contradiction pervaded U. S. foreign economic policy: the U. S. sought to lead the world toward freer trade but made no effort to lead the world toward a monetary system which produced equilibrium exchange rates.[9]

Perhaps ironically, the victim of that contradiction was the United States itself. In August 1971, the U. S. decided that it *wanted* to adjust its exchange rate—largely for domestic reasons but also in belated realization that it had to do so to restore the prospects for a liberal U. S. trade policy.[10] However, it found itself confined by a monetary system which made it very difficult for the U. S. to devalue, the only economically effective means of adjustment which would be politically acceptable in the relatively closed U. S. economy. It was thus caught in its own policy contradiction.

The U. S. was able to evade this contradiction until 1971 for two reasons. In the 1950's, it faced little serious international competition. Throughout the 1960's, its internal economy boomed; profits rose to record levels in 1966 and stayed there for several years, and unemployment dropped steadily toward the post-Korea low achieved in early 1969. Only in the 1970's has the U. S. come to face simultaneously real international competition and an unsatisfactory internal economic situation.

This is why the United States pushed so hard for the Smithsonian and early 1973 exchange-rate realignments and has begun to push for fundamental reform of the international monetary system. The basic aim of those proposals is to improve greatly the balance of payments adjustment process, by placing major international pressure on both surplus and deficit countries to move promptly and in adequate magnitudes to rectify any imbalances which they develop. Achievement of such a new monetary system, to help avoid any sizable or sustained disequilibrium in the exchange rate of the dollar in the future, is a necessary condition for the avoidance of further U. S. trade restrictions.[11] Tangible results from the Smithsonian and 1973 realignments, in terms of improvement in the U. S. trade balance, are also necessary to demonstrate the effectiveness of the exchange-rate approach.

The Trade Balance and Level of Trade

The second key issue is whether U. S. trade policy should focus on the trade *balance* or on the *level* of U. S. trade.

One American point of view is that the other major countries should be willing to grant nonreciprocal trade concessions to the United States, to help the international adjustment process which finds them in trade and payments surplus and the U. S. in trade and payments deficit. Former Treasury Secretary Connally openly espoused this view, confusing the appropriateness of minor trade concessions in the context of an overall effort to restore short-term payments equilibrium (as in the fall of 1971), if countries choose to extend them rather than revalue their exchange rates further, with the inappropriateness of sizable nonreciprocal concessions in a negotiation over the long-term level of trade barriers which, as noted above, must proceed on the assumption that the monetary system will achieve balance of payments equilibrium.

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[8] For a theoretical explanation of the bias, see Bergsten [3, pp. 68–69]. The dollar appreciation amounted to 1.5 percent, depending on the method of calculation and the precise time period chosen.

[9] So perhaps the Treasury Department should at least share the blame usually leveled at the State Department for "selling out U. S. economic interests."

[10] It must never be forgotten that it was the desire of the U. S. to adjust, not any Triffinesque collapse of the dollar overhang, which motivated the international aspects of President Nixon's New Economic Policy in August 1971. See Bergsten [2, pp. 200–204].

[11] Many Americans believe that such a system must be firmly in place before the U. S. can resume pursuing a liberal trade policy. This would mean a continued drift toward protectionism, since it will probably take some time to install formally the new regime. I do not share this view on timing, though it is admittedly tempting to try to use the threat of protectionism to speed the pace of the monetary talks. I believe that steady progress toward agreement on the needed reforms, plus their ad hoc implementation in individual cases in the interim, should suffice to lay a foundation for new trade liberalization—which itself would not begin to be implemented until a similarly distant point into the future.

Another school of thought reasons that the U. S. can afford to agree to a "reciprocal" reduction of trade barriers only when its trade balance again becomes strong, for four reasons. First, "reciprocity" in tariff negotiations has traditionally been defined, very crudely, as equality in the products of the average percentage cuts in duties times the volume of trade affected.[12] For example, "reciprocity" is achieved between two countries if each reduces its duties on $1 billion of trade by an average of 10 percent, or if one reduces duties on $2 billion by an average of 5 percent while the other reduces duties on $500 million by an average of 20 percent.[13] This school feels that price elasticities of demand for imports are higher in the United States than in other countries, so that equiproportionate tariff cuts from the relatively equal tariff levels that now exist in the major countries would have an adverse effect on the U. S. trade balance.[14]

Second, whatever the static effect on price elasticities, this school argues that the U. S. cannot afford "reciprocal" trade cuts at the present time because it is so uncompetitive in world markets that the dynamic effects of reducing trade barriers will be unfavorable to the U. S. trade balance. On this argument, the U. S. should avoid any new trade liberalization until it it has first established a better underlying foundation of productivity growth and control of domestic inflation.[15] This school of thought was promulgated by the Kennedy Administration in the opposite direction, when it argued that the Kennedy Round would help solve the U. S. balance of payments problem by enabling the U. S. to capitalize on its highly competitive international position to increase further its trade surplus (and reduce unemployment at home in the process).

The third part of this argument is that U. S. energy imports will rise by about $25 billion between now and 1980, making its trade position that much more difficult to balance. And the final strand is that "U. S. negotiators are always soft," because the U. S. always wants to bring negotiations to a successful conclusion for broad political reasons and hence are outdone in purely commercial terms by their foreign counterparts. The U. S. trade balance is thus bound to suffer from whatever is finally agreed.

In my view, there is some intellectual merit in each of these viewpoints. There is a place for nonreciprocal trade liberalization by countries running balance of payments surpluses, if they choose to adjust in that way. A much more sophisticated definition of "reciprocity" is clearly needed, as will be discussed below. The U. S. will certainly have to improve its competitive position to assure avoidance of trade balance deterioration as a result of new trade liberalization, especially in light of pending increases in energy imports, and will be unable to do so if other countries hamstring U. S. exports in the two areas where they are strongest—agriculture, as Europe particularly is already doing, and high-technology goods, where the industrial policies that Japan, Europe, and Canada are in different stages of developing could have similar effects. And the U. S. did extend nonreciprocal trade concessions, at least in the early postwar period, due to broad political reasons which it (correctly) deemed of overriding importance at the time.

None of these considerations, however, should dominate U. S. trade policy. The objective of trade policy should continue to be maximization of the welfare effects of international commodity flows. This may call for increasing or reducing the level of flows at any given time, for reasons we will come to shortly, but it is independent of trade balance considerations.

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[12] Preeg [7, esp. p. 132 and note 20]. He notes that additional considerations were often factored in on an ad hoc basis but that the basic formula was as stated in the text.

[13] "Reciprocity" has thus been defined in terms of changes in *absolute* trade levels. Some observers, including Government officials, have however erroneously viewed "reciprocity" as meaning equal *percentage* rises in each country's exports and imports. This would increase the level of all existing trade surpluses and deficits and move away from, rather than toward, payments equilibrium. Thus it would certainly not be acceptable to deficit countries. Nevertheless, this view seems to be widely held in the U. S., strengthening the policy conclusion of some that trade liberalization is in the U. S. interest when the U. S. is running a trade surplus but is not when (as now) it is running a trade deficit.

[14] Unfortunately, none of the economic analysis to date on price elasticities by country is sufficiently reliable to base policy on. One of the most elaborate efforts, Houthakker [4], provides tentative support for this school of thought by deriving a U. S. price elasticity for imports (adjusted for serial correlation) of −1.03 and much lower elasticities for all other major countries except Canada and Denmark. A host of other issues, such as "disparities" between the dispersion of individual tariffs around the averages in the different countries, complicates the matter further.

[15] These factors are important in the competitiveness of agricultural as well as industrial products. See Sorenson [8, pp. 819–820].

The appropriate trade balance for a country can be determined only by the needs of its overall balance of payments, which may call for changes in the trade balance in either direction at any given time. Over time, the trade balance needed for payments equilibrium may change in response to structural changes in other parts of the balance of payments, e.g., the sharp and steady rise in U. S. income on its foreign direct investments. In addition, the external payments positions of virtually all countries fluctuate between surplus and deficit several times within a decade; we often forget that Japan was in payments deficit as recently as 1966–67, and the U. S. was in payments surplus as recently as 1969. And the competitive position of an individual country can change very dramatically between the start of a trade negotiation and the completion of the liberalization resulting from it. The Kennedy Round, for example, spanned a full decade which started with the U. S. in a dominant competitive postwar position and actively *seeking* new markets for Japanese exports, and ended with a sharp reversal between those two countries. Finally, reductions in trade barriers probably reduce the flow of foreign direct investment, some of which is motivated by the need to get behind such barriers. This has some effect on trade flows; helps the balance of payments of a capital-exporting country such as the U. S. in the short run and hurts it in the long run; and has indeterminate effects on both the trade and payments balances at any given point in time.

Any major negotiation on trade barriers, however, sets the level of world trade restrictions for many years. Since it would be impossible even to tell which countries should benefit in trade balance terms from nonreciprocal concessions and which countries should extend them, let alone the magnitudes of such targets or even how the dynamic trade effects of liberalization would work out, the trade balance could hardly be the focal point for trade negotiations. Indeed, most countries can only win internal political agreement to reduce their import barriers by pointing to the equivalent gains to their exporters which are inherent in a "reciprocal" negotiation; it is inconceivable that European governments would, to put it provocatively, "sacrifice their farmers so that American multinational firms could continue to buy up Europe." No country could be sufficiently confident of its future payments position to negotiate consciously a decline in its trade balance in such a context.

Nevertheless, there is need to link the trade balance and trade policy in an operational way. Indeed, the monetary reform proposals of the United States do so by suggesting that countries have the option of adjusting their payments surpluses by unilaterally reducing trade barriers instead of revaluing exchange rates. The problem with this idea is that such a step would reduce the bargaining position of any such country in the next round of international trade negotiations and might reduce the incentive of other countries to pursue additional trade negotiations in the future. The Schultz proposal thus needs to be amended in two ways: countries would get credit in the next trade negotiation for trade liberalization undertaken earlier for purposes of payments adjustment, and they could restore their previous barriers if they moved clearly into payments deficit before the next round of trade talks (in which case they would get credit only for the duration of the temporary liberalization). If there is any role for trade policy measures in the adjustment arsenals of deficit countries, it is for surcharges applied across-the-board to all imports for a temporary period of time; those who seek quota protection for particular commodities to help the balance of payments are still another school of thought, but one not worth serious discussion.[16]

Reciprocity

Two aspects of the problem of reciprocity require discussion. On the technical level, new concepts are needed to replace the crude techniques applied in the past to tariff reductions. Wholly new techniques will be needed to measure "reciprocity" in the reduction of nontariff barriers, of which quantitative restrictions are the simplest but still raise difficult problems. The objective in all cases must be to quantify the changes in trade flows which are likely to result from particular changes in trade restrictions, to give countries a much sounder gauge than they have had heretofore of whether the outcome of their bargaining over trade barriers will in fact be truly reciprocal expansion of trade flows in both directions. Such improvement may have to be limited to equalizing the static effects of changes in barriers, since the dynamic effects are so much more difficult to measure,[17] but that would still represent major progress.

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[16] The United States has also proposed the use of import surcharges by the international community, or by individual countries, as sanctions against surplus countries which refuse to take steps to eliminate their surpluses. Such "sanctions" will always in fact be applied by someone; the U. S. import surcharge of August 1971 was such a step against Japan. The issue is whether they will be applied by individual countries outside any international framework, or by the international community as a whole. I would strongly prefer the latter.

A further technical problem is how to handle limits to import growth, such as the Burke-Hartke proposal for restricting imports to a fixed share of U. S. consumption. Retaliation in the past (as in the "chicken war" of 1962–63) has always related to actual rollbacks in trade, not limits to its growth. The problem could become particularly important in any new negotiation if new "safeguard" clauses are adopted along with cuts in tariffs and nontariff barriers. The simplest approach would be to extend the principles of the past by letting Country B place quantitative limits on a magnitude of its imports from Country A similar in both regards to the limits placed on its exports by Country A—emulation rather than retaliation in the conventional sense.

Such a search for better estimation techniques would further complicate a negotiation which already promises to be quite complicated. Countries could haggle endlessly over the accuracy of contending elasticities and over formulas for converting nontariff barriers to tariff equivalents. Improvement over past practices will almost certainly be needed, however, to achieve agreement on "reciprocal" liberalization among the major traders of today, all of whom are intensely concerned about their trade balances and may prove unwilling to liberalize at all unless they are assured of a "neutral" effect. And I indicated above that I see merit, not demerit, in extended (even constant) negotiation among the major trading countries.

This problem of adequately defining "reciprocity" was avoided in the past largely because the United States *was* willing—rightly, in my view—to accept liberalization which was not fully reciprocal from the standpoint of the U. S. trade balance in the short run.[18] The U. S. did so both because it was confident that its competitive ability would enable it to offset quickly any static economic losses with dynamic gains,[19] and because it had a major foreign policy stake in seeing that each of the succeeding trade negotiations concluded successfully. As in the monetary case, however, both the economic and international political situations have reversed; the U. S. will now insist on full reciprocity in short-term trade balance terms.[20] U. S. trade policy, and the outlook for international economic cooperation, are thus again hampered by the legacies of a successful past. Because the traditional concept of "reciprocity" has been discredited in the U. S. through its "misuse" in the past, a new concept will probably be needed if political support is to be generated for a new round of liberalization.

The more substantive aspect of reciprocity is whether the U. S. should offer concessions in the industrial sector in an effort to obtain concessions in the agricultural sector. It has been estimated that net U. S. exports might rise by $3 billion if all agricultural trade barriers were removed, although this figure omits consideration of sugar (and a few commodities of minor trade importance) and thus may overstate the likely impact.[21] However "reciprocity" were defined, this would of course require reductions in barriers to industrial trade which would increase net U. S. imports of such products by similar amounts.[22]

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[17] For example, no one negotiating the Kennedy Round, even at its conclusion, could have foreseen the deterioration of U. S. competitiveness due to its internal inflation in the immediately succeeding years.

[18] Similarly, the willingness of the U. S. to eschew adjustment of its balance of payments position enabled other countries to achieve their trade (and payments) balance goals more easily. However, it is interesting to note the recent rejection of the Supplementary Chemicals Agreement to the Kennedy Round by the EC, on the grounds that the EC would now lose from the deal in trade balance terms. In this case, at least, U. S. negotiators apparently made a magnificent bargain for the United States, since one must view the U. S. gain in this deal against the massive deterioration in the *overall* U. S. trade balance since 1967.

[19] This probably goes far to explain why U. S. labor supported free trade in the past, but does not now: they used to perceive that increased trade meant *more* jobs, whereas now they perceive that it means *fewer*.

[20] Of course, the real gain to the U. S. from trade liberalization is the welfare benefit of reducing present restrictions plus, since trade policy is dynamically unstable, the avoidance of welfare (and international political) costs imposed by the new restrictions which would otherwise take place.

[21] West [9, pp. 19–20]. Johnson [5] estimates an increase of $5 billion in gross exports of U. S. *and Canadian* grains and oilseeds; he makes no net calculation for the U. S., but his data confirm the broad magnitudes of the West estimate.

First-round economic welfare considerations would of course support this kind of intersectoral reciprocity. But there are offsets. Consider domestic job effects. Farm exports are highly capital-intensive, and even their sharp increase under free trade would produce relatively few jobs. The increased industrial imports, many of which would be in lower skill industries, would by contrast be much more labor-intensive and eliminate far more jobs. To be sure, domestic macroeconomic and manpower policies could recoup the lost jobs, but the costs of doing so—including budgetary and other inflationary effects—have to be set against the welfare gains of the freer trade.

Long-term trade balance considerations might also be negative. On the one hand, there is a case for such a deal because the U. S. appears to have a clear comparative advantage in agriculture, which is now largely unexploited, whereas it might well continue to lose ground on the relevant industrial items even without a further reduction of U. S. trade barriers. On the other hand, trade in most industrial items would tend to grow faster over time than trade in agricultural products. If the net result was to force future devaluations on the U. S., additional negative welfare effects would offset the original gains from improving the allocation of resources. These structural considerations suggest that the welfare effects of such a trade could be negative in the U. S. even if it achieved true reciprocity in trade-balance terms.

Whether the U. S. should seek to trade industrial for agricultural concessions also turns on domestic political considerations. There are four political arguments which favor it: further solidification of the support of the farm bloc for liberal trade, the demonstration effect of tangible rewards for a community which has maintained a liberal trade stance, the view of the farm community that the U. S. *gave* concessions on farm trade in return for industrial concessions in the Kennedy Round, and the great importance to overall U. S.-European relations (and hence to the world economic order) of getting meaningful European concessions on an issue which has been a focal point of the growing U. S. antagonism toward Europe.

There are two political drawbacks of making such a trade. One is the problems it would raise with the U. S. agricultural producers now protected by import barriers (mainly in the dairy, sugar, and beef industries), whose short-term interests would have to be sacrificed to minimize the net concessions granted on industrial trade. The second is those industrial interests whose protection would be reduced further to compensate for the foreign concessions on agriculture—which is particularly important because none of the favorable job effects would accrue to the unions which would suffer most of the unfavorable job effects and because these very unions are the leaders of the whole present protectionist push.

On balance, I would go for the trade on both economic and political grounds, because the welfare effects are probably close to neutral and because I place high priority on the political importance of breaking the present U. S.-EC conflict over agricultural trade. However, I fear that neither the Europeans nor Japanese will give us the choice. Europe is not sufficiently interested in U. S. concessions on industrial trade to make the tough internal decisions which would be necessary to liberalize the CAP and does not seem to understand that new restrictions on such trade will probably result if forward progress is not made. Indeed, in joining the Community, Britain has raised its duties on farm imports and lowered its duties on industrial imports—giving the U. S. reciprocity opposite to what is suggested here.

Internal Adjustment to External Disturbances

Another assumption underlying the policy conclusions of classical trade theory is full employment. In the U. S., however, excessive unemployment has existed frequently throughout the postwar period. It certainly does so now and adds to the difficulties of pursuing a liberal trade policy.

But the problem is not just the aggregate rate of employment. The AFL-CIO supported the Trade Expansion Act in 1962 when the rate was 5.5 percent, but had become protectionist by 1969 when the rate had dropped to 3.5 percent. A major factor is changing value preferences. Most American workers have now entered the lower middle class and achieved income levels at which they place much higher emphasis on job stability, relative to higher wages, than they could afford to do in the past. Reluctance to give up community, home, schools, and church may dominate the opportunity for marginally higher income, particularly in the absence of vesting of pensions and transferability of other fringe benefits from one job to another, for individual workers and for the labor force as a whole. American labor thus increasingly resists change—particularly change emanating from abroad, which is "different" in at least its susceptibility to successful resistance (and may also be substantively different due to the accelerating pace at which it is taking place). This attitude is greatly reinforced by the bureaucratic interests of the AFL-CIO, which knows that structural change of the U. S. economy means movement out of the highly organized, traditional manufacturing industries (such as steel and textiles) into the highly unorganized, modern high-technology and services industries.

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[22] Most analysts agree that farm trade can be liberalized only through efforts to align domestic farm policies, rather than attacks on barriers to farm trade per se. I abstract here from the method by which farm trade is liberalized.

This increasing resistance to change clashes head-on with the increasing pace of change itself. A mix of two approaches will probably be needed to cope with this clash, if a complete restrictionist relapse is to be avoided. Of critical importance will be a vastly improved adjustment assistance program, especially for workers displaced by imports. Adequate compensation and effective retraining and relocation programs will be necessary components of any such effect. Unfortunately, the record of manpower programs to date—not only in the United States, where they are now prime candidates for budget cuts, but in countries such as Sweden which have much longer and more comprehensive experience with them—is not encouraging.

The other approach is to slow the pace at which disturbances occur by limiting the permitted growth of imports. It is quite likely that new mechanisms will in fact be required to "safeguard" against any massive dislocations at least from new trade liberalization that takes place. Agreement on how they might work was the major area of progress recorded in the recent Rey Report to the Secretary-General of the OECD [6, pp. 83–84]. One aspect of that proposal was that application of any such safeguards "should be accompanied by action to bring about domestic adjustment so that the use of the safeguard mechanism will in fact be temporary," linking the two approaches in order to avoid undue reliance on new controls.

The Foreign Reaction

The final ingredient needed to avoid a continued and probably accelerated restrictionist trend in U. S. trade policy is a cooperative stance by other countries, in two senses. First, they will have to tolerate a much tougher U. S. trade policy than they have experienced in the past. The U. S. has already begun to administer its antidumping and countervailing duty laws with increased vigor and to bargain much harder over the level of particular concessions than it has in the past—not to mention the excesses of the fall of 1971. This will be necessary to erase the legacy of the "soft positions" of the past and to establish sufficient credibility for any Administration to win Congressional and public confidence in its ability to negotiate major new trade liberalization without "selling out the U. S. interest." At a minimum, it is clear that other countries can no longer look to the U. S. always to take the lead in launching negotiations and in making concessions to break logjams so that the negotiations will succeed. Indeed, as both the largest world trader and the largest problem for world agricultural trade, Europe should exercise a special responsibility for launching new trade talks.

Second, other countries will have to be willing to make concessions on issues of real importance to the United States, such as the level of agricultural support prices in Europe and real market access in Japan. They may also have to be willing to renegotiate some of the basic GATT rules which govern both trade flows and trade relations, to make them more relevant to present conditions. For example, the MFN rule may need to be modified, to require compensation for trade diversion inherent in the new kinds of "free trade areas" represented in the EC's Mediterranean policy and to permit discrimination against countries which cause particularly severe trade and/or balance-of-payments problems. New rules are needed to cover issues not now treated in the GATT, or treated inadequately, but which have become sufficiently important to warrant some such international treatment (e.g., foreign direct investment and multinational corporations, environmental protection policies, regional and other industrial policies, export subsidies).

To be sure, it will be intellectually and politically difficult for these countries to make the needed adjustment in their views. It is hard to reverse the momentum of a generation, and the signs that they will do so are not promising at present. Yet they must realize that the very foundations of the international economic system are at stake, that their actions will have major effects on U. S. internal politics, and act accordingly.

Fortunately all countries have a common long-run interest in avoiding new trade wars, which would disrupt both their domestic economies and world politics, and in working together to construct a new international economic order and to deal with such joint problems as energy imports and multinational firms.[23] The new tripolar economic world which is now dominated by the United States, the expanded European Community, and Japan provides them with plenty of scope for shifting coalitions in search of particular short-term goals. The U. S. and Japan together oppose Europe's discriminatory restrictions against Japanese exports and its proliferating preferential arrangements. The U. S. and Europe together oppose Japan's continued import restrictions and unbridled export surges. Japan and Europe together seek to eliminate some present U. S. trade barriers, certainly wish to avoid new U. S. restrictions, and probably join in opposing the U. S. effort to free world agricultural trade. As long as these coalitions shift from issue to issue, they could form a stable basis for moving ahead on liberalization through a series of high-level policy trade offs.[24]

Conclusions

It will obviously be difficult to achieve major progress on all the issues discussed in this paper within even the next few years. If the conditions outlined do not overstate what is needed, one must conclude that the outlook for reversing the trend of U. S. (and world) trade policy is dim. If this is true, the best that can be hoped for is minimizing the creep of additional restrictions while progress is made on the several needed fronts.

The early commencement of international negotiations on a limited range of issues, even in the absence of new Congressional authorization for the U. S. to liberalize, is one of the necessary steps. But even such negotiations are unlikely to produce much change in world trade in agricultural products.

The outlook for freer trade in farm products is thus close to nil, in at least the short run, with a far greater probability of increased protection as internal policies, especially in Europe, continue to distort the markets for agricultural output.

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[23] A further international political complication is that the less developed countries may oppose a new multilateral trade negotiation, even though they would not be required to extend reciprocal concessions, because it will erode the value of their newly won tariff preferences. This position is extremely short-sighted. On the one hand, the preferences are not very meaningful in economic terms (and the U. S. has not even extended any). On the other, the economic health of the LDCs rests fundamentally on healthy economic relations among the DCs. If a major new trade negotiation is needed to avoid continued slippage toward a world of trade restrictions, the LDCs—who need market access for their exports even more than do the DCs—would be among the major beneficiaries.

[24] See Yalem [10, pp. 1051–1063], for an analysis of international political tripolarity which is broadly relevant to these considerations of international economic tripolarity.

References

[1] Bergsten, C. Fred, "Crisis in U. S. Trade Policy," *Foreign Affairs* 49:619–635, July 1971.

[2] ———, "The New Economics and U. S. Foreign Policy," *Foreign Affairs* 50:199–222, January 1972.

[3] ———, "The United States and Greater Flexibility of Exchange Rates," in *Approaches to Greater Flexibility of Exchange Rates: The Bürgenstock Papers*, ed. George N. Halm, Princeton, N. J., Princeton University Press, 1970.

[4] Houthakker, H. S., and Stephen P. Magee, "Income and Price Elasticities in World Trade," *Rev. Econ. Stat.* 51:111–125, May 1969.

[5] Johnson, D. Gale, "The Impact of Freer Trade on North American Agriculture," this issue.

[6] OECD, *Policy Perspectives for International Trade and Economic Relations*, 1972.

[7] Preeg, Ernest N., *Traders and Diplomats*, Washington, The Brookings Institution, 1970.

[8] Sorensen, V. L., and D. E. Hathaway, "The Competitive Position of U. S. Agriculture," in *United States International Economic Policy in an Interdependent World*, Washington, Government Printing Office, 1971.

[9] West, Quentin M., "World Trade Prospects for U. S. Agriculture," *Am. J. Agr. Econ.* 54:827–833, Dec. 1972.

[10] Yalem, Ronald P., "Tripolarity and the International System," *Orbis* 15:1051–1063, Winter 1972.

Prospects for Freer Agricultural Trade

JOHN SCHNITTKER

PROSPECTS for freer agricultural trade are poor to only moderately good as we look to the formal beginning of a general trade negotiation late in 1973. At the same time, prospects for expansion of the volume of trade in agricultural products in the 1970's appear to be rather good. If both these statements are accurate, then agricultural trade expansion is not dependent on trade liberalization or freer trade, although the rate of expansion surely is. Forces other than liberalization of the world's trading rules and procedures would expand trade, even while a number of important trading countries are taking actions which would be considered trade restrictive.

In judging prospects for freer trade to be limited in the 1970's, I refer especially to the agricultural trade restrictive measures associated with the enlargement of the European Communities, the very deliberate rate at which Japan has been increasing her imports of certain products while slowly but surely limiting her agricultural economy, and the political leverage farm groups have in the U.S., to prevent or limit actions leading to freer trade in products the U.S. imports (or would import under a regime of freer trade) while pressing for agricultural trade concessions abroad for U.S. exports.

In judging prospects for expansion of agricultural trade to be rather good in the 1970's, I have in mind the continuing growth in incomes and in the demand for livestock products, the inexorable increase in Japan's grain and oilseed imports, the continuing difficulties in the USSR (entirely apart from 1972's crop failure) in producing enough grain and oilseeds to match its meat production targets, the new trade relationship of China with the rest of the world, and indications that even as the Green Revolution spreads, the developing countries will experience great difficulty in meeting their food needs. These developments will almost inevitably lead to substantial expansion of world trade in grains and oilseeds and their products, items which constitute an overriding share of trade in temperate agricultural products. This trend, at least for grains, cannot be expected to take off from the 1972–73 level, which will be some 15–20 percent higher than ever before achieved because of the spectacular crop failure in Russia, but from the average level achieved in the past 2–3 years.

The fact that agricultural trade has expanded these past 10 to 15 years despite the failure to achieve general trade liberalization, and the tantalizing prospect that agricultural trade will expand again in the next 10 or 15 years without regard to the outcome of pending agricultural trade negotiations will surely limit the interest of Western Hemisphere farm groups in the negotiations that are scheduled to begin in 1973. This is not to say that farm groups or agricultural analysts in exporting countries do not believe there is gold to be found in trade liberalization. Rather, it means that the surface layer will be mined first—taking the trade that comes easily. At the same time, negotiators and the interested pressure groups would continue to go through the motions of renewing their claims to the rich vein of expanded trade buried under layers of EEC and Japanese protectionism in the form of high domestic price guarantees and other trade restrictive practices relating to farm products. It would be generally recognized that the trade results associated with more rational domestic farm policies abroad would be realized only over a long time period.

The developed world finds itself today in an agricultural situation similar to that of the early 1960's, when the Kennedy Round of trade negotiations began. Agricultural issues were papered over or set aside in the Dillon Round of 1959 to 1961, and resolutions taken to do better next time. A certain amount of rhetorical recrimination was required in agricultural and political circles to keep this past failure in sight, so as to reduce the risk of repeating it in the Kennedy Round. Europe was in the early stages of implementing a Common Agricultural Policy, which had been designed to protect European producers, and, implicitly, to reduce access of agricultural exporters to European markets. The CAP was being implemented in stages, to become generally effective about the time the Kennedy Round was to be concluded. A more diabolical timetable for failure to achieve liberalization in agricultural trade, that is, changes in domestic farm policies and other

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regulations toward the objective of expanded trade, could scarcely have been conceived.

Now, another round of trade negotiations is about to begin. Governments have pledged their support and leadership; working parties are working; negotiators are trying to find their way through a labyrinth of detail toward some general plan of attack. In agriculture, we again find Europe going both directions at once. The EEC is in the process of consolidating its expansion by extending the Common Agricultural Policy to three new members. The transition from Britain's, Ireland's, and Denmark's national agricultural policies, which were relatively constructive from the trade standpoint, to the CAP will begin shortly and will conclude in 1977 or 1978. The Nixon Round of trade negotiations will begin ceremonially in late 1973. A closing date of 1974 or 1975 has been mentioned, but it is more likely to conclude in 1976 or 1977, unless it collapses or is phased so as to be continuous, rather than to end in a climatic crisis, as did the Kennedy Round.

But to return to the parallel, the EEC, whose CAP has been and will be one of the principal barriers to freer trade and the main target of the exporting nations, will find itself on both sides of the trade liberalization fence. It will be a party to a trade negotiation in which substantial liberalization of agricultural trade will be one of the key objectives, and for certain countries, the cornerstone. Yet the EEC will be expanding its highly protectionist agricultural policy to three new countries, and perhaps raising its price guarantees, all at the same time. The parallel with the Kennedy Round is unmistakable, and the result may well be the same, unless the objectives are substantially revised or the terms redefined.

There is danger of getting on another collision course in the 1970's. Consider what U.S. spokesmen had to say about EEC grain policy in October at the GATT Working Party on Accession to the European Communities:

> Enlargement of the European Community by the accession of the United Kingdom, Denmark, and Ireland, will have a major impact upon international grain trade and upon the legitimate interests of traditional grain exporting countries. The latter countries now export about 75 million tons of grain annually, and one third of this is accounted for by imports of the enlarged EC. . . .
>
> Adoption of the CAP will have a dramatic effect on the grain price structure in the acceding countries. Grain price increase will be sharpest in the United Kingdom. For example, United Kingdom protection, including producer payments, at the end of the transition period compared with 1971–72 levels would rise as follows:
>
> Wheat up 48 per cent;
> Barley up 52 per cent;
> Rye up 107 per cent;
> Prices paid by United Kingdom consumers would show even more drastic increases.

Those words were written as part of an argument designed to recover some value from damages about to be inflicted upon world trade in grains between the exporting nations and the EEC as a result of the CAP's expansion. But there is no reason to expect that the EEC will decide not to follow through with the agricultural policy transition, only a question of what the higher price guarantees will do to trade, what value can be placed on the lost trade, and how to compensate for it. In principle, the question of what level of guaranteed prices will prevail when the transition is completed is still open, since price decisions are made yearly. Barring miracles, we can anticipate grain price guarantees in the EEC at continued high levels; production will be stimulated and consumption restricted in the three new member countries, just as in the Six in recent years.

In such a climate, what may we expect from the EEC by way of proposals for agricultural trade liberalization or trade expansion in the 1970's.? I suggest we should expect very little. Trade expansion is not on Europe's agenda in the 1970's, except for internal trade and special cases. Rather, the EEC will focus on market organization when it talks trade with the rest of the world. Market organization means setting international trading prices or price ranges for key agricultural commodities higher than recent 3-year average levels, although probably lower than EEC internal prices. This means limiting the volume of trade while possibly increasing its value. Such proposals have nothing to do with traditional trade liberalization, but they have a certain logic for Europe. In fact, if the U.S. had the means of adhering to higher world trading prices when commodity supplies are adequate, and if the complex questions of equivalent prices for various qualities, and national market shares could be worked out, such proposals would have a marvelous appeal to U.S. producer groups, although not to the international grain trade. But in the unlikely event such arrangements could be worked out, trade volume would probably be restricted in comparison with the results of continuing with existing restrictions to trade.

Nations exporting large amounts of agricultural products will not be much more constructive on the question of freer agricultural trade where it really counts, that is, on those products they import or would import in large volume except for existing restrictions on such importation. U.S. farm organizations have been fast friends of freer trade principally because, in the U.S. farm context, that means reduced levels of protection in other countries and expanded U.S. agricultural exports. When reduced levels of protection for dairy products, cotton, sugar, or peanuts are discussed, protectionist views generally prevail in the U.S. farm community. The same is true in Canada and Australia, and this will change only slowly and under pressure from government.

Pursuing Self-Interest as Well as Negotiations

The political pressures and the economic rationale for trade restrictive domestic agricultural policies have arisen principally out of the concept agricultural pressure groups in various countries have of their own self-interest and that of agricultural producers. The rationale for political actions by governments aimed at limiting the protective impact of agricultural policies and realizing to a greater degree the benefits of international division of agricultural labor by consumers will have to arise out of a similar political assertion of self-interest by other groups. This is difficult and will probably take a long time. Urban and consumer groups are not highly organized in most countries, and making a direct challenge to trade restrictive agricultural policies is seldom near the top of their political action agenda. Governments also tend to be more responsive to organizations and traditions which have developed out of the past than to political groups which are just emerging.

If a government is to follow the self-interest of the majority of its citizens in the matter of agricultural price guarantees, budgetary expenditures, food prices, and trade, it must find ways of judging what that interest is. Little definitive study has been devoted to this question so far as agricultural policies are concerned. Yet I believe there is a broad intuitive judgment among economists and the public that if all the costs and benefits could be weighed, the customary defensive responses by governments to external challenges to their most protectionist agricultural prices and income programs have cost more over recent decades and generations than carefully timed remedial actions would have cost over a similar time span. Such remedial or compensatory actions would not represent a retreat from long-standing public and treasury commitments to farm people, but would be a means of compressing adjustment and income payments into a limited time period, while helping certain farm people and their children to shift into new lines of employment. Decisive agricultural actions of this type have seldom been taken by governments, except on a token or pilot basis, because the organizational and power base needed to prepare seriously for the future has seldom been as powerful as the groups organized to slow the future or to preserve the past. The slow progress on restructuring European agriculture, and the virtually total neglect of restructuring assistance in the U.S. are current demonstrations of this fact.

Major trading nations will find themselves on rather different time-tables over the next two decades in amending their domestic agricultural policies in a manner that would expand agricultural trade beyond the levels that will prevail under existing policies. This results from the differing stages of economic development and differing balances of political power in various countries. As a result, the time-honoured tradition of reciprocity in trade negotiations, to the extent it must be applied within agricultural sectors, is not a very useful rationale for altering domestic agricultural policies of major countries. The underlying notion that imports are inherently bad for a country while exports are good, and that tariff reductions (or domestic farm policy changes that would have similar effects) by a country benefit other countries most of all is an insidious and self-defeating concept.

Transferred to the idea of altering domestic agricultural policies in ways which would expand trade, the desire on the part of countries for a degree of intrasector reciprocity is simply a formula for not improving agricultural policies, even when over the short or long-run it is clearly in the public interest to do so. In the future, the U.S., for example, should look at its price support level for milk and the associated quantitative restrictions on dairy product imports, or at its subsidy payments to cotton and wool growers, in terms of its own interests as broadly conceived, and not in terms of what other countries are about to do in such matters. If it is in the public interest to rely more on butter imports than in the past because American farmers demand a very high price to produce enough butter to meet the demand, we should not wait until Europe is in a political position to lower its grain price guarantees, or until Australia agrees to import more tobacco to make a move in respect to U.S. milk prices.

Similarly, if the U.S. is to limit or terminate export subsidies for wheat, tobacco, or rice, while preserving its competitive position in other ways, it should do so because, on balance, it is good policy and because it represents the way America wants to spend public money in the years ahead. If other nations will take reciprocal actions regarding their own farm policies, so much the better. But we should not expect much.

I find the prospective Japanese moves to increase imports of agricultural products most interesting, especially since they are motivated by internal considerations, rather than by formal negotiations, or reciprocity.

By careful timing, it might also be possible to use the occasion of such unilateral actions on agricultural policy by one country to encourage other countries to take what would appear to be reciprocal actions, but would be, in fact, actions they were going to take in the interest of their own consumers or taxpayers when the proper occasion arose. Thus, what would appear to be agricultural negotiations would actually be a series of agricultural policy orchestrations. Individual countries may want to package agricultural policy changes made for domestic reasons in the tinsel of an international negotiation at certain times. However, the real impetus for constructive, trade-expanding moves on domestic agricultural policies in the 1970's and 1980's will usually be internal.

For example, the U.S. government recently terminated the export subsidy that had been applied to tobacco in 1966. This subsidy, in retrospect, was probably unnecessary to the U.S. competitive position, and will not be missed. The export subsidy on feed grains was ended about 12 years ago, without damage to the U.S. competitive position. The export subsidy on wheat, suspended this year some 3½ months and several hundred millions of dollars too late, can probably be forgotten, even when wheat supplies and prices return to more normal levels. Its principal function has been to keep U.S. market prices higher than they would otherwise have been, not to expand exports. Each of these actions would have been useful offers in a trade negotiation. Fortunately, the Government did not wait for a negotiation, but moved in response to other events.

Various countries are in different positions with respect to the internal possibilities for improving agricultural policies in a way that would expand agricultural trade. Japan, despite its continued high level of protection on agricultural products, has for the past ten years given the world an important example of limiting its agricultural policies in the interest of import expansion without apparent reciprocity on the part of other countries. Japan embarked many years ago on a policy of increasing reliance on agricultural imports, and this is continuing. Japan's growing import demand arose partly from limited agricultural resources and partly from basic changes in the pattern of food consumption associated with higher levels of income. These income patterns seem likely to continue. Japan, with some difficulty, could probably have held the importation of cereals over the past ten years to lower levels and could have relied more heavily than she has upon foods produced at home. Instead she went the route of greater reliance on imports. Japan is now becoming reconciled to a situation in which agricultural pursuits by most cultivators will be a subsidiary activity, with income from non-agricultural sources being most important to the family. There is still much room for improvement in the structure of Japanese agriculture and agricultural policy. Yet it is generally expected, because of increased demand for livestock products, that her imports of agricultural products will increase rather rapidly over the coming decades, almost without regard to what kind of agricultural policies Japan pursues, or what the rest of the developed countries do. The new Government may move more swiftly toward greater reliance on imports than had been expected, as noted above.

The European Economic Community will one day find itself in a position similar to Japan today. Demands for agricultural products will rise more rapidly than Europe's ability to produce them at reasonable prices, even with a rapidly changing agriculture. This will coincide with a rise in urban political power. The time for this is still some distance away. Europe has the technological capacity to increase agricultural production materially in the 1970's, so long as price incentives are kept high. Thus, the potential market for agricultural products in Europe will tantalize but probably disappoint agricultural exporting nations in the 1970's and 1980's. European governments and the EEC Commission will find themselves unable to meet the political challenge required to turn increasingly to agricultural imports, while compensating for rapid agricultural change with the gains from food imports. The prospects for change would be enhanced if Treasury Ministers there were having a strong influence on agricultural expenditures, but so far they are not, and I do not expect them to.

The great problem the rest of the world faces now with respect to Europe is to find ways to help the EEC avoid further increases in the level of agricultural protection as it expands in the 1970's. A great deal of momentum has been generated by eight years of increasing levels of protection under the Common Agricultural Policy, and by the decisions taken in connection with enlargement of the EEC. The political lessons of that period have not been lost on the more sophisticated and better financed farmers of the 1970's, including those in Britain, Denmark, and Ireland who are about to share in the CAP for the first time. Perhaps the pressure of a general trade negotiation will be useful as a defense against new increases in protection that would otherwise develop, but not to begin a reduction in agricultural protection.

The American role in furthering progress toward freer agricultural trade in the decade ahead can take several forms. Like Europe, the U.S. is in some danger of falling back into old agricultural policy errors. Some farmers and their representatives still want "cost of production," including a market return on the capitalized value of land, and "full parity prices." Some producers in the U.S. believe world trading prices for grains have been too low most of the time, and remain willing to search for the means of raising them, possibly through higher domestic price guarantees and even through pricing formulas in commodity agreements, despite the poor results so far. Avoiding the error of a new and costly round of producer subsidies on export crops is one contribution the U.S. can make in the 1970's. The battleground on this question will be in Congress, where attempts will be made to fix higher price or subsidy guarantees, and in the Executive Branch, where the budget managers will try to reduce the more flagrant welfare payments to already prosperous farmers. Making permanent the recent actions terminating, or at least limiting, export subsidies on wheat, rice and tobacco, would certainly be constructive. Phasing down producers subsidies to cotton growers, the real purpose of which are to encourage production of cotton for export in competition largely with developing countries, would also be generally applauded.

A second approach would be to take some small initiatives toward increased agricultural imports where it would hurt least at home. Dairy products and beef offer the best prospects, and a start has been made on the latter under the pressure of recent high prices. When the Sugar Act is renewed in 1974, imports could be given a larger share. But the U.S., like other countries, will move toward greater agricultural imports largely for its own reasons or not at all, and not because Europe will reform the CAP or because Japan has reduced the duty on soybeans. The force of good example in trade relations is very limited compared with the power of budgetary restraint. Only when nations decide that agricultural protection costs too much will freer trade be realized on a faster timetable. Until then, we can rely with some confidence on a slow expansion of world trade in major agricultural products, with the traditional exporters sharing the principal benefits.

The Impact of Freer Trade on North American Agriculture

D. Gale Johnson

North American agriculture has much to gain from freer trade in farm products and from freer trade generally. It is true that some sectors would be required to make significant resource adjustments and in some instances significant capital losses would result from reductions in protection. But the major sectors of North American agriculture—the sectors that employ most of the labor, land and capital—would gain from a significant expansion in demand. If the reduction in barriers to trade in farm products would reduce the average rates of nominal protection to approximately the same as the protection of industrial products, the expansion in demand for the output of North American agriculture probably would be sufficient to return to cultivation all the land that has been idled by government programs in the United States and permit the relaxation of the marketing limitations that prevail in Canada.

The strong conclusions about the impact of freer trade on North American agriculture are based on three major assumptions: major sectors of North American agriculture have significant degrees of comparative advantage; the sectors of agriculture that have a comparative disadvantage utilize a relatively small percentage of the land and labor resources engaged in agriculture; and freer trade in agricultural products among the major industrial countries would result in a large expansion in the value and volume of international trade in farm products. Each of these assumptions will be considered in turn.

Comparative Advantage and Disadvantage of Major Farm Products

Based on work that has been reported elsewhere [5, 8], assuming approximately the prices of farm products in international markets in recent years, the following ranking of the comparative advantage of major farm products can be made:[1]

Clear Comparative Advantage	Uncertain	Clear Comparative Disadvantage
Feed grains	Rice	Manufactured dairy products
Corn (US)	Cotton	
Barley	Flaxseed (US)	
Grain Sorghums (US)	Tobacco (C)	Sugar
Oats (C)	Pork	Wool
Oilseeds	Beef	Lamb and mutton
Soybeans (US)	Oats (US)	
Rapeseed (C)	Corn (C)	Peanuts
Flaxseed (C)		
Wheat		
Tobacco (US)		
Poultry		

Because both the United States and Canada have farm programs that influence production and marketing decisions for several of the farm products, the fact of exports does not prove that a particular product is produced at a comparative advantage. However, in estimating the comparative advantage status an effort has been made to determine the nonland costs of production and what the probable advantage position would be if the programs were eliminated. It should also be noted that recent international prices do not reflect what prices would be if there were free or substantially freer trade in farm products. However, two independent estimates [2, 6] of the changes in international prices if there were free trade indicate that changes in relative prices would be relatively small, with the largest changes occurring for farm products that North America produces with a clear comparative disadvantage (manufactured dairy products, especially butter, and sugar). International prices of feed grains and wheat would either remain unchanged or increase slightly. International prices of beef would increase and might shift North America into a position of a small comparative advantage for some grades of beef (choice and prime) though with continuing substantial imports of lower grade breef for manufacturing.

Farm programs in the United States transfer significant amounts of income to farmers for both wheat and feed grains. In recent years payments under the wheat program have been about 40 percent of cash receipts from marketings; the similar percentage for feed grains has been 30 percent. However, until 1971 over half of all feed grains—in some years as much as 60

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[1] Where there is some difference in the comparative advantage positions of Canada and the United States, this is indicated by insertion of (C) or (US) after the commodity.

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percent—was produced outside the feed grain program and for the market price, which reflected the export price. Farmers who did participate in the program were required to divert or set aside substantial quantities of cropland, and a significant part of the payments under the feed grain program was required to compensate farmers for the rent on the diverted land. The comparative advantage position of wheat is somewhat more difficult to disentangle because of the retention of export subsidies (approximately 10 to 15 percent of the farm price in most years since 1964) and the much greater importance of payments relative to the value of production. But estimates of the difference between nonland costs of production and the market price indicate that in the absence of payments wheat production would still be quite profitable in the United States and that elimination of the wheat program would result in an expansion of wheat output at recent export prices.

Canada has provided only modest levels of protection for the feed grains, though through the operation of the Canadian Wheat Board and, more important, large subsidies for the internal transportation of wheat, the nominal protection of wheat production has been rather substantial—perhaps of the order of 20–25 percent [7, pp. 66, 75].[3] But in Canada, as in the United States, the primary effect of reducing subsidies would be to lower the price of land rather than significantly affect the output of wheat. In most recent years Canadian wheat output has been influenced by marketing restrictions or by special programs to reduce the area devoted to wheat such as the LIFT program in 1970. Even if the removal of subsidies and other governmental measures resulted in some contraction of wheat production in North America, which I doubt, most of the resources would be transferred to the production of feed grains or to forage for cattle.

North America has a clear comparative advantage in the production of oilseeds. No significant subsidies have been involved in the production of soybeans, except for P.L. 480 disposal of oil, and rapeseed or flaxseed. In fact, the U.S. feed grain program has probably restrained soybean output because soybeans cannot compete with the payments for voluntary diversion or set-aside.

Most products in the uncertain category are there either because governments programs may have been maintaining output above the free trade level or because it is anticipated that freer trade could result in a shift toward expansion of either imports or exports. There is only limited world trade in pork, except for lard and cured products. Beef is a highly diverse product and was commented on earlier.

Resource Use by Products with a Comparative Disadvantage

The fraction of the agricultural resources of North America used to produce farm commodities with a comparative disadvantage is quite small. The only important sector that is involved is manufactured dairy products.

Other farm products in this category—sugar, peanuts, wool, and sheep—are quite minor in their relative resource use. The crop area devoted to sugar in North America totals only 2.2 million acres or only 0.5 percent of the total cultivated area; even if sugar land is considered three times as valuable as other cropland, the percentage of total value is only 1.5 percent. In the United States (mainland) only 1.5 percent of all direct farm labor used on crops and livestock is devoted to sugar; the percentage for Canada is substantially smaller.

Peanut production, concentrated in the southern part of the United States, requires less than 0.4 percent of North American cropland and about the same small percentage of total direct labor. Under free trade peanut production would be reduced substantially, but it would probably not be entirely eliminated.

Based on animal unit conversions for the United States, sheep use no more than 2 percent of all feed (grain and roughage) in North America and probably a smaller fraction of all labor.

In North America all dairy cattle constituted approximately 20 percent of the total cattle herd in 1970. Based on feed use in the United States, all dairy cattle consumed about 17 percent of all livestock feed. But only about half of all milk produced is used for manufacturing purposes. The remainder is used for fluid consumption and would continue to be produced in North America under free trade. Nor would milk used for manufactured products be entirely displaced by free trade. There are two primary reasons: first, if there were general free trade in manufactured milk products, the international prices of such products would increase very substantially and some North American output would be profitable at those prices; second, because of seasonal and daily variation in supplies, a significant amount of milk would be available for manufacturing as a joint product of fluid use. This amount on an annual basis would be approximately half of the fluid use. Thus the maximum reduction in total milk production in North America would be of the order of 25 to 30 percent. At the extreme, reduction in milk production would diminish feed use by about 5 percent or the equivalent of about two years of growth in North American feed use. Direct reduction in labor requirements would be somewhat less than 5 percent, though the total reduction, including labor used to produce feed, would be about 6 percent.

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[3] The estimate is for 1965 through 1969.

The total of the adverse effects of free trade on the demand for farm resources would be less than 10 percent for both land and labor and probably not more than 6 percent for land and 8 percent for labor.

Expansion of Trade

If there were only a moderate degree of protection of farm products—say 10 to 15 percent—the increase in international trade for grains, manufactured dairy products, sugar, beef, and oilmeals—would be substantial. There might also be a significant expansion in tobacco trade, though since the effect on North America would be fairly small, nothing more will be said on this point. As noted above, North America would import substantial quantities of manufactured dairy products and sugar under free trade.

It is not altogether clear how North America would fare with respect to beef. With free trade in beef, the price of the type of beef imported into North America—beef for manufacturing purposes—would increase quite significantly. North America does not produce very much beef of the type imported, and production has been declining and would decline further as dairy production would decline under competition from imports. Thus both the quantity and value of such beef imported would increase though the increased quantity would displace domestic production to only a minor degree. If there were only nominal protection of beef in the major industrial countries, I believe that an export market for the fed beef produced in North America would develop. The major market might well be Japan, but there could also be an important outlet in Western Europe. Perhaps the major limiting factor on such exports could be the difficulty of expanding production in North America to meet a rapidly growing domestic demand at real prices near those now prevailing. Under low nominal protection of feeds as well as beef in Western Europe, the price of beef should decline significantly. I have estimated elsewhere [4, pp. 89–90] that beef consumption in Western Europe would increase by about a million tons if there were free trade in grains and beef. While some part of the additional beef would be produced in Western Europe through transfer of resources now used for grains, a significant part would be imported. Since North American fed beef could be sold in Western Europe at approximately the current prices of much lower quality beef, significant exports from North America could materialize.

A major expansion of beef production in North America would require fuller use of land now diverted under farm programs in the United States and perhaps some diversion of land from grain to pasture in both Canada and the United States. The major limiting factor in expanding beef production is production of calves, not the concentrated feeds to fatten calves and young beef animals. While much can be done to improve the carrying capacity of existing pastureland used for beef cows and calves, expansion of beef production to meet rather rapidly expanding domestic demands plus a modest level of exports would make possible a more effective use of land resources in North America than is now possible.

In my opinion, there would be a substantial market for North American fed beef in Japan. As a matter of policy, beef consumption has been kept extremely low in Japan. Per capita beef consumption remained unchanged between 1955 and 1967, despite the enormous growth in per capita incomes, at about 2.5 pounds per capita. While some increase in beef imports has been permitted in the last three years, per capita consumption has increased to no more than 4 percent of the North American level. Where the livestock product could be produced in Japan (pork, poultry, eggs, and milk), per capita consumption increased by three to eight times between 1955 and 1967 [4, p. 92].

If Japanese beef and veal consumption increased to only a quarter of the North American level—probably a low figure for the end of this decade if the Japanese were permitted by their government to purchase beef at reasonable prices—beef and veal imports would be at least a million tons. If a significant fraction were fed beef, the import cost would take care of more than an eighth of the present current account surplus in the Japanese balance of payments.

There is little likelihood of a significant expansion of international trade in pork if there were free trade. The hog is apparently a ubiquitous animal; except for cured products, locally produced pork products are generally preferred over foreign or imported products which would now generally be frozen and thus subject to a discount in most markets. There is considerable debate about whether North America would be a major exporter of poultry products under free trade. I would guess, and it is little more than that, that the rate of effective protection of poultry production in the Common Market is at least 25 percent. This is based on an import levy that provides nominal protection of 7 percent after full reflection of higher feed grain prices. Some would argue that the higher feed grain prices are more than fully reflected in the sluice gate price due to substitutions among feeds (some of which enter duty free) and a failure to adjust the formula to reflect reductions in feed requirements. The full technology of broiler production has not been quite as easy to transplant as it was originally thought to be.

Expansion in trade in the grains that would follow from free trade would have the greatest impact upon resource use and prices in North America. During the last half of the 1960s North America exported about 21 million tons of feed grains and 30 million tons of wheat.[3] Total production averaged about 160 million tons of feed grains and 58 million tons of wheat.

Free trade in grains would have two important effects upon the volume and value of international trade. The first would be a reduction in production in Western Europe and Japan; the second would be a significant increase in consumption of feed grains in the same regions. The consumption effect, in the case of feed grains, would probably be somewhat larger than the production effect and, it should be remembered, the two effects would be additive so far as import demand is concerned. It is not clear that Japan would have the production capacity to produce all of the meat, poultry and dairy products that would be demanded under a free trade situation. For pork and poultry such a possibility probably exists, but not for beef and dairy. However, whether the beef and dairy products are produced in Japan is largely irrelevant to the demand for feed grains produced in North America. If the dairy products imported into Japan were primarily produced in Western Europe, the West European demand for feed grains (and oilmeals) would be increased as a result. If the beef imported from Japan were produced primarily in Oceania, the feed grain exports from Oceania would be substantially reduced.

If it is assumed that Japanese consumption of livestock products in 1980 would be one half the 1960 U.S. level, total grain exports from North America in 1980 might be close to 100 million tons or nearly double the level during the last half of the 1960s. Comparison with 1960 U.S. consumption levels is based on the FAO projection that in 1980 per capita consumption expenditures in Japan would be at the 1960 U.S. level.

Of the projected increase in exports of grain from North America, slightly more than half would go to Japan or to produce livestock products for export to Japan and about a third would go to Western Europe. Small additional quantities would go to Eastern Europe and to some of the developing countries. In these rough projections it is assumed that grain exports from Argentina and Australia would increase by nearly as much as the increase in North America. If Japanese per capita consumption of livestock products were to increase to approximately 75 percent of the 1970 U.S. level by 1980 or a somewhat later date, the expansion of grain exports would be perhaps 10 million tons greater than projected above.

Free trade would result in a significant expansion in the export demand for North American oilseeds. At the present time the oilseeds are not faced with significant import restrictions and, in fact, heavy protection of grain in Western Europe has encouraged use of oilmeals by distorting the price relationships between feed grains and oilmeals. But the substantial expansion in livestock production that would result from free trade would be quite favorable to oilseed and oilmeal exports. With no change in farm policies and protection, it has been projected that U.S. soybean exports would increase by 75 percent between 1970 and 1980 [1]; Canadian exports of rapeseed, starting from a much lower level, would probably increase as much. Almost all the effect of free trade on the oilmeals would be a consumption effect; most major importers of oilmeals do not produce oilseeds in significant quantities. And, as noted, some effects of free trade would be to reduce consumption of oilmeals *per unit* of livestock output because of changes in price relationships. But the expansion of livestock production should be large enough to result in some increase in oilseed and oilmeal exports, perhaps by as much as a third. It needs to be recognized that further expansion of oilseed output to meet protein feed requirements will have a depressing effect upon vegetable oil prices.

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[3] All references to tons are metric tons.

The value increase in North American grain and oilseed exports would be approximately $5 billion if one assumes that the price effects of free trade would be 10 to 15 percent for grains and 20 percent for oilseeds. This expansion in demand should be sufficient to return all diverted land in the United States to cultivation and to permit the removal of various marketing restrictions that exist in Canada. I do not mean to say that all 60 to 65 million acres of diverted land would return to annual cultivation in the United States. In 1950–53 when demand was strong and crop prices relatively high and there were acreage allotments in only one year, 70.9 million acres of cropland were neither harvested nor pastured [9]. In 1964 when 55 million acres of cropland were divered under the farm programs, the total cropland neither harvested nor pastured was 89.8 million acres [10]. Over the same period the land in summer fallow increased by 13.4 million acres or by 70 percent of the increase in idle or fallow cropland. It is unlikely that elimination of the farm programs would result in much decrease in the amount of summer fallow because most of the change in summer fallow area over the past two decades can be explained on the basis of changing cost relationships, including increased labor costs and the declining price of nitrogen.

In addition the anticipated increase in demand for beef should result in some part of the land now used for crops or land that is truly diverted being converted into permanent or rotation pasture. Thus the amount of land that would return to crops in the United States could hardly exceed 20 million acres and it could be rather less.

However, if there were free trade in agricultural products, North American farmers would have to forego some rather substantial subsidies that they now receive. In the wheat and feed grain sector in the United States these payments amounted to $2.4 billion in 1970 and rather more in 1971 and 1972. In Canada the subsidies are significantly less important and have been estimated by the USDA to have been $242 million in 1969.

Resource Demands in 1980 with Free Trade

If current agricultural and trade policies of the industrial countries are maintained to the end of this decade, several recent projections indicate a rather gloomy outlook for North American agriculture. The most recent projections made by FAO for 1980 indicate that export availabilities of wheat and coarse grains would exceed import requirements by more than 60 million tons or by more than the total of North American exports in recent years [2]. Obviously such an excess supply would not be generated, but much of the adjustment would of necessity have to be made in North America as the major grain exporter—approximately 60 percent of the world's total in recent years. FAO projections indicate a faster growth of export availability than of import requirements for oilseeds, though North American exports could continue to expand though at a lower rate than during the 1960's. Projections made for the United States and Canada lead to similar conclusions. USDA projections indicate that it may be reasonably expected, with no changes in agricultural and trade policies, that domestic and export demand for farm products would increase by 18 percent during the 1970s [1].[4] But this projection was made without taking into account the enlargement of the European Common Market, and population growth in the United States may have been overestimated by 2 or 3 percent. These two factors could bring the growth in demand for U.S. farm output down to 12 or 13 percent for the decade.

Projection studies of farm exports generally are based upon one of two approaches: a projection of export availability, the residual between domestic production or use; and a projection of export demand, based upon certain assumptions about the policies, production, and demand in importing and competing exporting countries. FAO followed the first approach. The Canadian Federal Task Force on Agriculture followed the second approach and projected 1980 grain exports at 12 million tons (10 million tons of wheat) [7, pp. 98–100]. This projection implies no important change in the level of Canadian grain exports by the end of the decade. It is clear, however, that at recent levels of real farm prices, Canadian production of grain could increase substantially during the decade. Culver projected slightly more than 40 percent increase for U.S. grain exports between 1967–69 and 1980. But the U.S. projection was made without consideration of the enlargement of the EC. With enlargement of the EC and if the Soviet Union is not a net importer of grain in 1980, it is unlikely that 1980 North American grain exports would exceed the levels of the late 1960s.

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[4] Base for comparison has been changed from 1967–69 to 1969–71.

Some considerable part of the potential excess output of wheat in North America can be diverted to meeting the growing demand for beef. This would occur by shifting land and resources to the production of feed grains and by expanding the area of pasture. But even with this shift it is highly probable that total demand for agricultural resources during the decade would grow somewhat less rapidly than the capacity to produce at recent real farm prices and a continuation of current farm programs.

With free trade the expansion of demand for grains and oilseeds would go a long way and perhaps all the way toward full utilization of the agricultural resources of North America at recent real farm prices and perhaps result in some increases in those prices.

If summer fallow is included as a part of cropland utilized, approximately 90 percent of the cropland area of North America is used for wheat, feed grains, oilseeds, and forage crops. Except for the part of feed grains and forage crops used for dairy production, the area devoted to the specified crops either has a comparative advantage or is used for further processing by farm products either having a comparative advantage or where there would be no significant increase in imports if there were free trade. Based on earlier estimates of the effect of free trade on use of land resources by dairying, the reduced output of dairy products would result in loss of an outlet for about 5 percent of total land resources. Thus the expansion of demand would apply to approximately 85 percent of total cropland and a somewhat smaller fraction of total pasture.

While the fraction of labor resources that would be adversely affected by free trade would be small—approximately 8 percent—it cannot be concluded that the remaining uses would be directly and favorably influenced by the expansion of demand under free trade. Farm products with a comparative advantage, especially the grain crops, are labor extensive as one would expect. Based on U.S. data, the livestock and crops with a comparative advantage or no disadvantage utilize somewhat more than half of total direct labor. Fruits, vegetables, and cotton utilize nearly 20 percent of farm labor in the United States, though a much smaller fraction in Canada. Expanded demand for farm labor that would result from freer trade would not be large enough to prevent the long-run downward trend in labor use in agriculture. The net effect on labor use as of 1980 might be of the order of 5 to 10 percent, a modest offset to the probable reduction of a third in the farm labor force that would otherwise occur during the decade in North America.

Conclusion

North American agriculture could gain substantially from freer trade in farm products. The gain would not be without its costs since there are some sectors that are producing at their current levels only because of substantial protection. North American farmers cannot expect to obtain significant reductions in the barriers to their exports unless there is a willingness to reduce barriers for the farm products that would be imported in substantial volumes in the absence of such barriers.

References

[1] Culver, David W., "A View of Food and Agriculture," *Agr. Econ. Res.* 22:—, July 1970.

[2] Food and Agricultural Organization, *A World Price Equilibrium Model*, Committee on Commodity Problems CCP 72/WP.3, Nov. 11, 1971.

[3] ———, *Agricultural Commodity Projections, 1970–1980*, Vol. I, Rome, 1971.

[4] Johnson, D. Gale, "Agricultural Price Policies and Effects on Trade: Some Examples from the United States and Western Europe," in *Obstacles to Trade in the Pacific Area*, eds. H. E. English and Keith A. J. Hay, (Proceedings of the Fourth Pacific Trade and Development Conference), Ottawa, Carleton University, 1972, pp. 89–90.

[5] ———, "Where U. S. Agricultural Comparative Advantage Lies," Agr. Econ. Res. Paper 72:19, University of Chicago, 1972, mimeo (to be published by Atlantic Council in *U. S. Agriculture in a World Context* in 1973).

[6] ———, *World Agriculture in Disarray*, The Macmillan Co., 1973.

[7] MISSISEN, EDMOND, AND ARTHUR L. COFFING, *Canada: Growth Potential of the Grain and Livestock Sectors*, USDA ERS For. Agr. Econ. Rep. 77, June 1972.

[8] TRANT, GERALD I., "The Impact of Trade Liberalization on Canadian Agriculture," in *Trade Liberalization and Canadian Agriculture*, eds. Gerald I. Trant, David L. MacFarlane, and Lewis A. Fischer, Toronto, University of Toronto Press for Private Planning Association of Canada, 1968.

[9] U. S. Department of Agriculture, *Agricultural Land Resources*, Agr. Res. Service Ag. Inf. Bull. 140, 1955.

[10] ———, *Cropland Trends Since World War II*, ERS Agr. Econ. Rep. 177, 1970.

Discussion: D. E. HATHAWAY, *The Ford Foundation*

One cannot but be impressed, as I was, by the breadth of coverage and insights offered regarding the future of U. S. trade policies by Dr. Bergsten's paper. I am concerned, however by what I consider to be a major omission of importance to future U. S. trade policy. His paper, as does Professor Johnson's, concentrates on trade policy vis-à-vis developed market economies and by omission, ignores the importance of trade with LDC's and state-controlled socialist economies. To do so ignores 1972–73 and/or assumes that it will never happen again. I would argue that 1972 did happen and, moreover, that similar years of agricultural production and trade will occur in years to come. Unless we think about and accommodate for such occurrences both we and many other countries are likely to have unstable and unmanageable trade problems in addition to those already mentioned.

The year 1972 was one of unfortunate weather interacting with continued mismanagement of major portions of the world's agricultural resources. (I shall omit specifying which was which in order to avoid national sensibilities.) Traditional food grain exporters, such as Australia, Indonesia, and Thailand, were unable to export as expected. The two largest socialist states, China and the USSR, became major importers, and the overly optimistic bloom came off the green revolution, especially in India and Pakistan.

I would assert, without going into the supporting arguments here, that both bad weather and mismanagement are likely to continue to be major factors which will create great year-to-year instability in the level of trade in agricultural products and will create a larger than expected demand for agricultural imports in the LDC's and socialist economies. This will come on top of their demand for imports of sophisticated capital items.

For a variety of political reasons on both sides, I believe these demands must be met by trade mechanisms rather than by aid. Despite our current apparent willingness to give more generous trade terms to Russia than India, in the long run I suspect both will have to deal with the U. S. on a commercial trade basis. And neither the socialist economies or the LDC's, for quite different reasons, are going to subscribe to the difficult rules of monetary reform and exchange rates that Mr. Bergsten has outlined as necessary and desirable.

Thus, I believe that the U. S. and its wealthy trading partners must face three different but equally complex sets of considerations in their future trade negotiations. One is the set outlined so well in the Bergsten paper. The second is a mutual and reasonably consistent set of trading relationships with the relatively wealthy socialist economies, and the third is a special set of trading relationships with the LDC's.

Unfortunately, for both political and economic reasons neither the LDC's nor the socialist economies will be willing or perhaps able to meet the conditions for trade policy laid out by Dr. Bergsten. They will continue to focus on trade balance rather than level. They will continue to overvalue their currencies but, if necessary, underprice exports. They will continue exchange controls, import licensing, absolute quotas and prohibitions, and all the other devices that are anathema to free trade advocates. Most of all they will be unwilling or unable to force internal adjustments to external economic forces.

I cannot conceive that negotiations with the groups excluded from Dr. Bergsten's considerations can do anything but add difficulty to an already difficult set of trade negotiations. I think, however, that the political forces of the LDC's and the socialist countries, especially if aligned as they often are, will force the wealthy trading nations to face up and deal with these problems as well as those he has outlined. I believe the outcome may well be an expansion of trade but not a liberalization of trading rules as we now view them. Indeed, one might question whether expansion rather than liberalization is not a more meaningful concept outside academic circles.

I do not wish to give the impression that I expect either the LDC's or the socialist economies to become large sources of demand for either U. S. farm or industrial products on a regular basis in the immediate future. On the other hand, one cannot ignore the more than 20 million tons of grains exported to these countries in 1972–73 or the likelihood of continuation of appreciable exports in the future—*if the necessary trade arrangements can be made.*

Given the general decline in enthusiasm among recipients as well as donors for aid programs, I believe that we must look more realistically to commercial trade as an important factor in economic development. Thus, those of us who are still concerned with improvement of the well-being of the bulk of the world's population hope more attention is given to their trade problems and interests than has been the case in these papers and in the U. S. concerns in general.

Discussion: TIM JOSLING, *University of Guelph*

Views on trade liberalization in agricultural goods seem to fall in two categories. There are those that see the next few years as a period of confrontation when bargains will be negotiated, threats made, and concessions granted. Countries will have to give up some cherished parts of domestic policy to ease the way for progress in moving toward goals in other areas. Others see the way forward to lie essentially in the concentration of effort on improving domestic policies for the good of the country concerned, with or without the "orchestration" of such moves with other countries. John Schnittker is firmly in the second camp. There are indeed desirable changes which countries can make alone in their agricultural programs. Some will increase and others will decrease trade volume. But by concentrating on these, a number of fruitful and feasible moves are ignored.

Countries are broadly alike in their motives for wanting to negotiate on agricultural trade restrictions and the domestic programs that lie behind them. Each nation would primarily like to influence the policy of others. Put boldy, the reason for this is an overriding concern to expand or preserve the market for one's own producers. In exporting countries, arguments commonly rest on their position as "low-cost" or "traditional" suppliers; in importing areas there is agitation over "dumping" and assertion that the "world" market price is depressed and unrealistic. Such arguments come not only from pressure groups and lobbies, but more importantly from government spokesmen and in particular from Departments and Ministries of Agriculture. Governments find it worthwhile to expend considerable diplomatic energy on such "advertising compaigns"; they offer the chance to reduce domestic program costs and aid the adjustment of domestic agriculture. The rhetoric of trade liberalization often wrongly equated with trade expansion is used freely in support of such arguments.

A second reason for governments to negotiate is that many agricultural policies are themselves largely defensive in the sense that they are implemented to offset the effect to those of other countries. Export subsidies are a prime example; removal of such subsidies may be possible by negotiation where no country can or will act unilaterally. The concept of the variable levy, espoused by the EEC as the main instrument for the Common Agricultural Policy, was primarily a device to defend the European market against the subsidy policies of other countries.

Two other motives for negotiation in agriculture could be mentioned: to effect transfers to developing country producers through international price support and marketing schemes—again without the scope of individual countries—and to get a transfer of domestic resources among sectors by the process of swapping agricultural and industrial trade "concessions." The scope for negotiation on some or all of these lines is considerably broader than Schnittker suggests.

Schnittker is also too pessimistic on the possibility of change in Europe's attitude to agricultural trade. The CAP has already undergone a remarkable though somewhat *ad hoc* transformation. It may be worth summarizing the present CAP market support mechanisms. Though still thought of as the cornerstone of the policy, the *variable levy* is the main instrument of support only for feed grains. Most farm imports enter over fixed levies, in particular beef and oilseeds. The *derived levies* applied to imports of poultry, eggs, and pigmeat are also fixed, even though they incorporate a variable element to offset grain price differentials, in that foreign producers of these goods have some opportunity to compete by price. *Producer subsidies* are given on durum wheat and olive oil; *quotas* operate for sugar, and *two-price systems* help support the market for wheat, skimmed milk, and butter. This last policy resembles somewhat the marketing certificate system in the U. S. in its effect on the market. Finally, an *intervention-restitution* scheme supports the butter and wheat markets by providing a price floor; the levies on these commodities act much as the U. S. Section 22 quotas to prevent reimportation and excessive support cost.

The effect of the CAP on trade has been both creative, encouraging specialization within the EEC, and diversive, especially from countries such as Denmark which were excluded from former markets. The overall level of protection appears not to have increased with the formation of the CAP. Enlargement to include the U.K., Denmark, and Ireland will indeed limit the EEC market for farm goods; the one published study indicates that the "enlargement effect" for grains will be a market contraction of about 0.6 million tons each year by 1980 [1]. It is somewhat misleading to suggest that enlargement will change the "constructive" trade policies of new members. Both Denmark and Ireland had extensive export subsidy schemes and tight controls on imports; the U.K. had been gradually abandoning its role as an open market for the temperature zone commodities of the white commonwealth since 1961. Increase in producer prices expected in the U.K. during the transition to EEC levels is not out of line with those granted to farmers in the past four years. The impact on consumer prices will be more severe, and will help both to put internal pressure on the CAP and also to give the U.K. an incentive to seek a satisfactory outcome to the trade talks.

There appears in the last few months to be a more constructive attitude toward these talks within Europe. The European Summit meeting held in Paris in October led to a political commitment to suceed. The timetable is sufficiently tight to concentrate diplomatic minds. The analogy with the Kennedy Round is misleading. The transition arrangements for harmonizing price levels—a series of border tax adjustments like those following parity changes—are not a commitment to future policy or to prices. The full CAP is adopted as of February 1st, 1973; after that date policy changes affect all members. The policy at present is under review. There is a much more relaxed approach to such changes even in those European institutions that have been the most staunch defenders of the present system. A new and much more political "Commission" is about to take office, with ambitious plans to develop community programs in new areas. This places a more direct budgetary control over spending on farm support than has been the case until now. Pressures are building up to use the CAP as a possible weapon against inflation. Decisions on agriculture will no longer be in the exclusive hands of one Commission member and one body of the Council of Ministers. In the situation, Schnittker's pessimism regarding the substance of the talks on agricultural trade is not warranted; the prospects are brighter than for many years.

Reference

1] FERRIS, J., *et al.*, *The Impact on U. S. Agricultural Trade of the Accession of the U. K., Ireland, Denmark, and Norway, to the EEC*, East Lansing, Michigan State University Institute of International Agriculture, 1971.

Discussion: G. I. TRANT, *Canada Department of Agriculture*

Free trade in agricultural or other products has yet to be seen. Nevertheless, the free trade concept continues to be as useful for its prescriptive validity as it is exasperating for its illusiveness. If one assumes away the problems of attaining freer trade, one must agree in general with the theme and presentation of D. Gale Johnson's paper in which he argues that freer trade in farm products would result in a greater international movement of agricultural products and a significant benefit for sectors of North American agriculture having a clear comparative advantage such as wheat, feedgrains, oilseeds, tobacco, and poultry. At the same time one may consider that his statement on the attendant resource adjustment problems for those sectors with a comparative disadvantage is perhaps a bit bland even though relatively few human and other resources are involved. In the dairy industry, for example, there tends to be a regional concentration of comparatively disadvantaged production in parts of Canada and perhaps also in the United States which would have to face wrenching adjustments in resource payments not only for land but for capital and labor as well. It is small consolation to be part of a negatively adjusted global 8 percent when 90 percent of one's neighbors are facing the same adjustment in something other than a seller's market for labor. The social and private benefits and costs of freer trade are not the same in the presence of high unemployment as they are under full employment.

A few small items are worth mentioning before proceeding to comments of substance. The outlook under freer trade of increased effective demand for the livestock-feedgrains sector of North American agriculture does appear to be most encouraging whether one looks West or East. While most of this increase may well be in feed grains and beef, there are indications that significant increases are possible in pork and pork products. When price relationships have been favorable, very large quantities of pork have been shipped from North America to the United Kingdom, and such a market might well be developed again there or elsewhere for frozen, cured, or fresh product. The Japanese market, as a matter of fact, appears to be opening up for increased pork imports.

Johnson argues that the location of production of beef and milk for Japan is largely irrelevant to the demand for feedgrains in North America. This does not appear to be the case. If, for example, these products are produced in Japan, they would have to be produced under intensive high feedgrain using systems. These would obviously increase the demand for North American and Australian grain. If, however, the beef is produced in Oceania, the majority of it would continue to be produced under extensive pasture conditions without a compensatory reduction in feedgrain exports.

In his presentation, Johnson has in effect examined two polar positions. One is that of a continuation of current agricultural and trade policies of the industrial nations. This would produce most disturbing resource allocation problems for North American agriculture. The other is that of a close approximation to free trade. While one may fervently hope that present policies do not continue and, in fact, the upcoming GATT negotiations appear to offer some reason for optimism, nonetheless it is perhaps a great deal too much to expect that anything like his freer trade will emerge in the near future. What is required is an examination of workable alternatives to the two polar positions with a view to determining if they of themselves produce net positive benefits and, further, whether or not they can be manipulated in such a way that they lead to a trade in agricultural products free enough to produce most of the benefits of free trade.

To put the matter more concretely, it would be more useful to examine a commodity by commodity approach to trade liberalization. What, for example, would be the effects of free trade in all dairy products including freer trade in fluid milk in North America? It is not immediately evident that such an approach will produce either, all, or any of the benefits of free trade. Nonetheless, it may well be one of the viable negotiating alternatives at Geneva. Another alternative worthy of examination would be the outcome of applying the ten items, the "code of good conduct" suggested in the OECD High Level report. To the extent that they may well represent currently realistic maxima, they also are a most appropriate topic for consideration.

FINANCING AGRICULTURE AND RURAL DEVELOPMENT

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A Theoretical Evaluation of Alternative Subsidy Schemes for Regional Development*

MYRON G. MYERS, BARRY K. ROGSTAD, AND HARRISON G. WEHNER

THIS paper presents a model describing an analytical framework for conducting research on new tools and programs for economic development assistance. The subject of this paper is part of a larger research effort currently under contract with the Economic Development Administration (EDA) of the U. S. Department of Commerce.[1] In particular, the study is concerned with the selection and evaluation of particular subsidy programs to determine their relative usefulness in meeting the goals of EDA. The list of subsidy programs being examined includes, but is not limited to, regional development banks, investment tax credits, and wage subsidies. Other candidates are expected to surface during the course of the research effort and may include taxable municipal bonds and a negative value added tax.

Rather than addressing these specific subsidy schemes in the initial stages of the analytical portion of the study,[2] the model to be specified here provides a basis for identifying the relative advantages of "generic families" of subsidies, specifically, wage, capital, and price subsidies. The model seeks to evaluate each of these in terms of specific regions and specific industries. Key parameters of "target regions" and firms are specified and shown to be the principal determinants of the relative effectiveness of each type of subsidy. Target regions consist initially of representative and then of specific areas identified by factor supply conditions. Data for candidate firms are specified by the elasticity of factor substitutions and relative factor shares and are estimated on the basis of nation-wide industry production functions.

It is intended that the model will serve two major functions. First, it is designed to delineate broadly the impacts of wage, price, and capital subsidies. This function is basic to meeting the overall objective of analyzing new tools for economic development assistance. The model, in its present form, permits administrators of regional development efforts to identify the most desirable type of subsidy to be administered under alternative industry/region combinations. This paper deals only with the specification of the model required to carry out this first function.

Second, having developed a tool that will assist EDA in selecting the type of subsidy programs to develop (given its goals as well as its organizational and administrative constraints), it is intended that the model will be further developed to provide more specific analytical guidance to the consideration of other factors pertinent to the subsidization of a specific firm in a specified region. For example, the introduction of transportation as a third factor input as well as the influence of institutional conditions in banking are some of the considerations which are presently being addressed. These more detailed considerations are obviously specific to the particular region being studied and therefore cannot be generalized. Whether these additional factors will be embodied in the for-

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[1] The contract is from July 1972 through summer 1973. The analytic framework presented in this paper, therefore, is still in the process of being extended and refined, with a final version not scheduled for completion until spring 1973.

[2] Development of an analytic framework comprises only a portion of the overall study effort. An extensive review of foreign experience with regional subsidy programs has been undertaken with the hope that new forms of assistance might be suggested. In addition, the study team has spent considerable effort in assessing the political and administrative implications of alternative subsidy programs as perceived by the Congress and in the Executive Branch of the U. S. Government. As a result of these other activities, it is intended that the specific subsidies finally recommended will not only have passed tests of economic efficiency and cost effectiveness, but their administrative feasibility and acceptability from a political standpoint will have been taken into account as well.

MYRON G. MYERS, BARRY K. ROGSTAD, AND HARRISON G. WEHNER *are members of the staff of SYSTAN, Inc. in Washington.*

mal model or treated as specific issues, which can only be heuristically evaluated by policy makers, will be a function of the regions and industries selected for detailed analysis. In any case, it must be recognized that no analytic construct can systematically deal with all the factors which influence the selection of the optimal industry/region/subsidy combination. The form of the final model will therefore attempt to deal systematically with as many of the major issues as possible, being careful to specify the many other factors (many of them judgmental) necessary to make a final determination.

The Model

The purpose of the theoretical construct which follows is to discern the impact of various subsidy schemes on industries within regions. We make use of the behavior of a representative firm which is aggregated to produce a total industry impact. Each firm within an industry is assumed identical, to follow profit maximizing behavior, and to regard output price and factor costs as given. For the entire industry, variation in firm behavior produces variations in output and factor price. That is, each firm is so small that its individual action has no effect on output or factor price whereas the action of all firms in concert effects output prices and costs. These are the normal conditions which follow from the assumptions of perfect competition.[3]

Consideration will focus on a set of critical parameters, some of which are region specific, some industry specific, while others are simultaneously region and industry specific.

Region specific parameters comprise the factor supply elasticities. The labor supply ϵ_L indicates the responsiveness of additional labor hire to changes in the regional wage rate occasioned by shifts in industry demand for labor. The assumption made on the factor supply elasticity of capital is that it is available to the industry in unlimited amounts at an invariant price which coincides with the national cost of capital.

Industry specific parameters include the elasticity of substitution σ which summarizes the technology of the production process for firms in the industry. Instead of specifying a specific production function, a general (linear homogeneous) function is postulated with a constant elasticity of substitution in the range of variation under consideration. The benefit of this approach is that the effect of variations in relative factor costs can be assessed with respect to changes in factor proportions actually employed —the elasticity of substitution measuring the ability of firms to vary factor proportions technically. The industry demand elasticity η represents the demand curve facing the industry for production originating in the region. The industry demand curve for the region thus is a subset of the nationwide demand curve and reflects the amount of unit sales the industry can achieve at various prices (F.O.B.) were it to locate in the region. Regional demand elasticity η indicates the responsiveness of additional unit sales to variation in price. The final industry parameter represents the labor intensity of production that results from relative factor costs within the region and the technical ability of firms to vary factor proportions. The share of payrolls in value added, α, is chosen to embody the relative factor proportions utilized by firms in the industry.

For purposes of analytical convenience, a firm is defined as a standard unit of capital denoted as $\overline{K}$. Thus, a "firm" is, in reality, an arbitrary unit of capital so that an industry consisting of N firms comprises, in total, $N\overline{K}$ units of capital. We are *not* concerned with the size distribution of firms within the industry and hence do not distinguish between a firm of 10 units of capital versus one with 100 units of capital. For our purposes the two firms together entail 110 units of capital or 110 "firm" units.

$$(1) \quad X = F(\overline{K}, L) = \overline{K}f(L/\overline{K}) = Kf(Q)$$

$$(1.1) \quad X^* = \alpha Q^* = \alpha L^*.$$

The firm's production function, F, is assumed homogeneous of degree one so that $X/\overline{K}$ can be expressed as a function of labor per unit of capital (firm) $L/\overline{K}=Q$. Without any loss of generality, $\overline{K}$ can be set equal to one and X reinterpreted to represent value added per "firm," L to represent labor per "firm," and Q can be dropped as variable. Equation (1.1) represents the proportionate differentiation of (1) where * refers to proportionate rate of change.

$$(2) \quad P = g(N \cdot X)$$

$$(2.1) \quad P^* = 1/\eta(N^* + X^*) = 1/\eta(N^* + \alpha L^*).$$

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[3] For analysis akin to the model developed here, see Borts [1].

The demand curve faced by the industry in the region relates price P (F.O.B.) to industry output $N \cdot X$. Proportionate differentiation of (2) gives the percentage change in price as a function of the elasticity of demand η, and change in industry output $(N^* + X^*)$.

$$(3) \qquad P_k = F_k P / r$$

$$(3.1) \qquad r^* = F_k^* + P^* = uL^* + P^*.$$

Equation (3) embodies the assumption of profit maximizing behavior and states that the discounted marginal value product of capital equals the price of a unit of capital P_k. The discount rate r is the national cost of capital, capital being infinitely elastic in supply to firms in the region. Equation (3.1) gives the proportionate differentiation of (3) where P_k is a constant and where u is the elasticity of the marginal product of capital. Any lowering of r below the national cost of capital, expressed in proportional terms as r^*, is assumed to be due to the imposition of a capital subsidy program.

$$(4) \qquad w = h(N \cdot L)$$

$$(4.1) \qquad w^* = 1/\epsilon_L (N^* + L^*).$$

The regional labor supply curve is given by the function h which relates wage rate w to industry labor demand $N \cdot L$. Differentiation produces the proportionate change in the wage rate in terms of supply elasticity ϵ_L and the percentage change in industry employment $(N^* + L^*)$.

$$(5) \qquad w = F_L \cdot P$$

$$(5.1) \qquad w^* = F_L^* + P^* = vL^* + P^*.$$

The representative firm employs labor to the point where the wage rate, the marginal cost of labor, equals the marginal value product of labor (F_L is the marginal physical product of labor). Differentiation of (5) gives the percentage change in the wage rate in terms of L^* and P^* where v is the elasticity of the marginal product of labor.

The following relationships are easily established:[4]

$$u = \frac{\alpha}{\sigma}$$

where

$$\sigma = 1/(u - v), \quad u > 0, \quad v < 0$$

$$\sigma \equiv - Q^*/(F_L/F_K)^*$$

$$= \text{elasticity of substitution}$$

$$v = \frac{\alpha - 1}{\sigma}.$$

Plan of Inquiry

The model presented above will be utilized to assess the impact of three generic types of subsidy schemes. By impact is meant any one of a number of various consequences of a subsidy being sought by the government, including additional value added, additional employment, additional payrolls, and additional firms (capital) attracted to the region. The mission of the Economic Development Administration can best be described in terms of attempting to stimulate the development process. The first two of the above criteria (additional value added and employment) have been selected as the best proxies for meeting this goal. Discussion of benefits in the latter sections of this paper will therefore center around these two impacts.

The alternative subsidy programs to be investigated consist of a wage subsidy, capital subsidy, and factor neutral price subsidy.

The government may reimburse firms a fraction of their (hourly) wage payments which has the direct effect of lowering the firms' per unit cost of labor. This type of program will be denoted as a wage subsidy.

A more common form is a capital subsidy where a government agency lends to firms in a region at rates below the competitive loan rate. An alternative form of capital subsidy is the practice of lease or sale of capital equipment at less than market price. Note that a capital subsidy in either form has the effect of lowering the cost of capital relative to labor, while a wage subsidy changes relative factor costs in favor of labor. Hence, neither subsidy can be expected to be neutral with respect to factor use.

The third program to be investigated, a direct payment to firms in the region per unit of physical value added in the region, is neutral with respect to factor use and can be conceptualized as a negative excise tax. The subsidy will be referred to as a price subsidy and can be paid as a proportion of output price or total value added, but only in proportion to value added originating in the impact region.

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[4] See Borts and Stein [2].

To determine the relative effectiveness of these three generic types of subsidy programs, the analysis derives expressions representing the additional *benefits* (value added and employment) and concomitant dollar costs for each type of subsidy. The terms involve the various parameters previously described and the amount of subsidy actually offered, expressed as percentage rates.

Once these "impact" equations are derived, calculations will center on determining for each program the amount of subsidy which exhausts a fixed governmental budget. The percentage subsidy rates, determined so as to exhaust the budget, can then be utilized to calculate the additional employment and value added generated, and the various programs can be ranked on a cost-effective basis. This procedure is followed to place each subsidy on a cost-equivalent basis which in turn allows a ranking of programs via the resulting benefit streams.

Impact of Alternative Subsidy Schemes

Capital subsidy

Suppose that a capital subsidy program is offered which lowers the cost of capital, in percentage terms, by an amount r^* (alternatively, capital can be subsidized directly by a price reduction of P_k^*). Substituting an exogenous capital subsidy r^* into (3.1) and combining (4.1) with (5.1) gives

$$X^* = \alpha L^* \tag{6}$$

$$P^* = \frac{1}{\eta}(N^* + \alpha L^*) \tag{7}$$

$$r^* = P^* + uL^* \tag{8}$$

$$w^* = \frac{1}{\epsilon_L}(N^* + L^*) = vL^* + P^*. \tag{9}$$

Combining (6)–(8) and solving yields

$$N^* = \frac{[\eta(\sigma + \epsilon_L) - \epsilon_L\alpha(\sigma + \eta)]r^*}{\sigma(1 - \alpha) + \epsilon_L - \alpha\eta} \tag{10}$$

$$L^* = \frac{r^*(\epsilon_L - \eta)\sigma}{\sigma(1 - \alpha) + \epsilon_L - \alpha\eta.}. \tag{11}$$

Note that number of firms eventually producing in the region may increase or decrease since the sign of the numerator of (10) which may be positive or negative depends on relative size of the various parameters while the number of workers per firm decreases ($L^*<0$). The latter effect merely reflects the fact that as capital costs relative to labor costs decline, firms substitute in favor of capital.

To ascertain the overall *industry* effect on employment and output, it is necessary to consider the percentage change in total industry employment $(N\cdot L)^*$ and total industry output $(N\cdot X)^*$ where, for small changes, $(N\cdot L)^* = N^*+L^*$ and $(N\cdot X)^* = N^*+X^*$.

From (10) and (11)

$$N^* + L^* = \frac{(1 - \alpha)\epsilon_L(\sigma + \eta)r^*}{\sigma(1 - \alpha) + \epsilon_L - \alpha\eta} \tag{12}$$

$$N^* + X^* = \frac{\eta(1 - \alpha)(\sigma + \epsilon_L)r^*}{\sigma(1 - \alpha) + \epsilon_L - \alpha\eta}. \tag{13}$$

Observe that total industry employment increases, $(N^*+L^*)>0$, provided $|\eta|<\sigma$ and decreases otherwise. This means that the substitution effect against labor due to a lowering of capital costs must be compensated for by an expansion in total industry output if total employment is to increase. This can occur provided the industry demand is more elastic than the technical ability of firms to substitute capital for labor as the relative cost of capital falls.

Further, observe that there is always an expansion in physical output, $N^*+X^*>0$. Since

$$\begin{aligned} P^* &= \frac{1}{\eta}(N^* + X^*) \\ &= \frac{r^*(1 - \alpha)(\sigma + \epsilon_L)}{\sigma(1 - \alpha) + \epsilon_L - \alpha\eta}, \end{aligned} \tag{14}$$

the change in value added becomes

$$\begin{aligned} &N_0X_0P_0(N^* + X^* + P^*) \\ &= \frac{N_0X_0P_0(1 - \alpha)(\sigma + \epsilon_L)(\eta + 1)r^*}{\sigma(1 - \alpha) + \epsilon_L - \alpha\eta}. \end{aligned} \tag{15}$$

Expression (15) for the change in value added produces the result that the "direction" of the change depends only on the elasticity of industry demand; an inelastic demand leads to a reduced level of value added, while an elastic demand produces an increase in value added. The magnitude of the change, however, is dependent on the size of the remaining parameters and how they interact.

Finally are stated the expressions for additional employment and value added elicited by a capital subsidy r^* as well as the cost of such a subsidy:

(16) Additional Employment

$$= N_0L_0(N^* + L^*)$$

$$= \frac{N_0L_0(1-\alpha)\epsilon_L(\sigma+\eta)r^*}{\sigma(1-\alpha)+\epsilon_L-\alpha\eta},$$

(17) Additional Value added

$$= N_1X_1P_1 - N_0X_0P_0$$

$$= N_0X_0P_0(N^* + X^* + P^*)$$

$$= \left[\frac{N_0X_0P_0(1-\alpha)(\sigma+\epsilon_L)(\eta+1)}{\sigma(1-\alpha)+\epsilon_L-\alpha\eta}\right]r^*,$$

(18) Subsidy Cost

$$= -(r_1 - r_0)P_kK_0N_1$$

$$= -r_0P_kK_0N_0(1+N^*)r^*$$

$$= -r_0P_kK_0N_0$$

$$\cdot\left[1+\frac{[\eta(\sigma+\epsilon_L)-\epsilon_L\alpha(\sigma+\eta)]r^*}{\sigma(1-\alpha)+\epsilon_L-\alpha\eta}\right]r^*.$$

Wage subsidy

Next investigated is a program in which employers are reimbursed by a percentage amount of the prevailing wage rate. The effect of this type of subsidy is to shift the "net" or realized industry labor supply curve in the region by an amount t percent (Fig. 1).

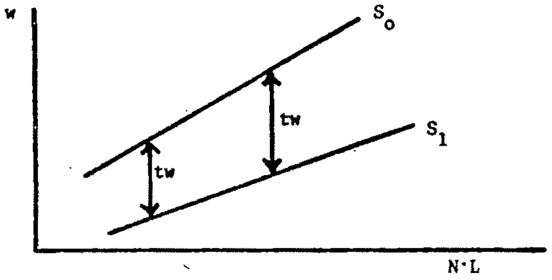

Figure 1

Analytically, this amounts to replacing equation (4.1) with:

$$w^* = \frac{1}{\epsilon_L}(N^* + L^*) - t \tag{19}$$

so that in the absence of any change ($N^* = L^* = 0$), $w^* = -t$, and wage costs to the industry fall by t percent. The system of equations now reads:

$$X^* = \alpha L^* \tag{20}$$

$$P^* = \frac{1}{\eta}(N^* + \alpha L^*) \tag{21}$$

$$r^* = 0 = P^* + uL^* \tag{22}$$

$$w^* = \frac{1}{\epsilon_L}(N^* + L^*) - t = P^* + vL^*. \tag{23}$$

System (21)–(23) can be solved for the equivalent expressions found when the capital subsidy was analyzed:

$$N^* = \frac{-\epsilon_L\alpha(\sigma+\eta)t}{\sigma(1-\alpha)+\epsilon_L-\alpha\eta} \tag{24}$$

where t is the wage subsidy in percentage terms.

$$L^* = \frac{\epsilon_L\sigma t}{\sigma(1-\alpha)+\epsilon_L-\alpha\eta}\,. \tag{25}$$

Note that L^* is always positive since (25) reflects only the substitution effect which prompts a substitution in favor of labor as the net wage rate is lowered while industry expansion (or contraction) depends on substitution versus expansion or σ versus η.[5]

$$N^* + L^* = \frac{\epsilon_L t[\sigma(1-\alpha)-\alpha\eta]}{\sigma(1-\alpha)+\epsilon_L-\alpha\eta} > 0, \tag{26}$$

$$N^* + X^* = \frac{-\epsilon_L\alpha\eta t}{\sigma(1-\alpha)+\epsilon_L-\alpha\eta}\,. \tag{27}$$

From (26) and (27) observe that there is always expansion in industry employment (substitution dominates the possible negative expansion effect) and physical output.

To express the costs that accompany imposition of a wage subsidy, it is helpful to construct a diagram of the regional labor market (Fig. 2). Additional benefits and resultant costs of the wage subsidy are the following:

(28) Additional value added

$$= N_1X_1P_1 - N_0X_0P_0$$

$$= N_0X_0P_0[N^* + X^* + P^*]$$

$$= \frac{N_0X_0P_0(\eta+1)(-\epsilon_L\alpha)t}{\sigma(1-\alpha)+\epsilon_L-\alpha\eta},$$

---

[5] Note that N^*L^*/t is the elasticity of derived demand for labor and is equivalent to the well-known Hicks [3] formulation when the "own" supply elasticity of labor is infinite.

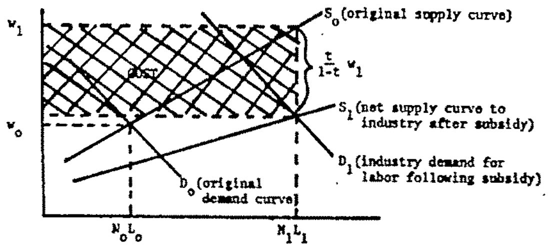

Figure 2

(29) Additional employment

$$= N_0L_0(N^* + L^*)$$

$$= \frac{N_0L_0\epsilon_L[\sigma(1-\alpha) - \alpha\eta]t}{\sigma(1-\alpha) + \epsilon_L - \alpha\eta},$$

(30) Subsidy cost

$$= tw_1N_1L_1$$

$$= tw_0N_0L_0(1 + w^* + N^* + L^*)$$

$$= \frac{t}{1-t}W_0N_0L_0$$

$$\cdot\left[\frac{(\epsilon_L+1)(\sigma(1-\alpha)-\alpha\eta)t}{\sigma(1-\alpha)+\epsilon_L-\alpha\eta} + (1-t)\right].$$

Price subsidy

Imposition of a price subsidy or bounty at a rate proportional to P has the effect of shifting the realized regional demand curve upward by an amount bP where b is the subsidy expressed in proportionate terms (Fig. 3).

The demand curve (2.1) is altered to read:

$$(31) \qquad P^* = \frac{1}{\eta}(N^* + \alpha L^*) + b$$

which together with the remaining equations of the model produce the system

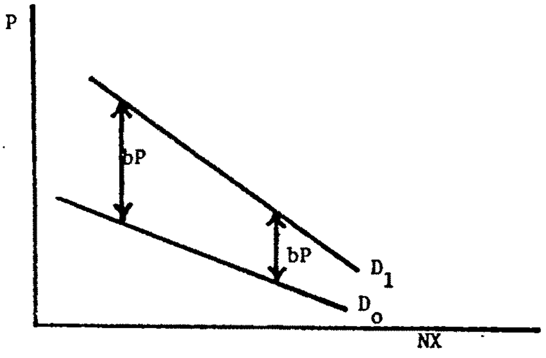

Figure 3

$$(32) \qquad r^* = 0 = P^* + uL^*$$

and

$$(33) \qquad w^* = \frac{1}{\epsilon_L}(N^* + L^*) = P^* + vL^*.$$

Solving (31)–(33) determines

$$(34) \qquad N^* = \frac{-\eta(\sigma + \epsilon_L)b}{\sigma(1-\alpha) + \epsilon_L - \alpha\eta} > 0,$$

$$(35) \qquad L^* = \frac{\eta b\sigma}{\sigma(1-\alpha) + \epsilon_L - \alpha\eta},$$

$$(36) \quad N^* + L^* = \frac{-\eta\epsilon_L b}{\sigma(1-\alpha) + \epsilon_L - \alpha\eta} > 0,$$

and

$$(37) \quad N^* + X^* = \frac{\eta[-\sigma(1-\alpha) - \epsilon_L]b}{\sigma(1-\alpha) + \epsilon_L - \alpha\eta}.$$

Figure 4 details the additional employment and subsidy costs arising from the price subsidy as given in (37)–(40):

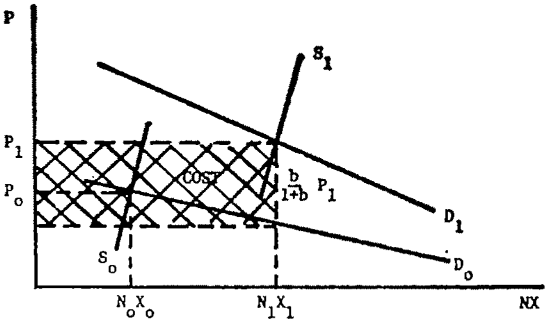

Figure 4

(38) Additional value added

$$= N_1X_1P_1 - N_0X_0P_0$$

$$= N_0X_0P_0(N^* + X^* + P^*)$$

$$= N_0X_0P_0\left[\frac{\eta[\alpha(\sigma-1) - (\sigma+\epsilon_L)]}{\sigma(1-\alpha) + \epsilon_L - \alpha\eta}\right]b,$$

(39) Additional employment

$$= N_0L_0(N^* + L^*)$$

$$= \left[\frac{N_0L_0(-\eta\epsilon_L)}{\sigma(1-\alpha) + \epsilon_L - \alpha\eta}\right]b,$$

$$
\begin{aligned}
(40)\quad & \text{Subsidy cost} \\
&= bP_1N_1X_1 \\
&= P_0N_0X_0[1 + P^* + N^* + X^*]\frac{b}{1+b} \\
&= P_0X_0N_0\frac{b}{1+b}\Bigg[(1+b) + (\eta+1) \\
&\qquad \cdot\left(\frac{\sigma(1-\alpha) - \epsilon_L}{\sigma(1-\alpha) + \epsilon_L - \alpha\eta}\right)b\Bigg].
\end{aligned}
$$

Theoretical Evaluation of the Cost-Effectiveness of Subsidies under a Budget Constraint

The dollar cost for each of the subsidy programs has been derived in terms of the various region and industry specific parameters and the actual magnitude of the subsidy offered (r^* for the capital subsidy, t for the wage subsidy, and b for the price subsidy). Suppose that the agency offering the subsidy has a fixed budget of B dollars which it desires to exhaust in order to obtain the greatest increase in employment or value added within the region. We first calculate the appropriate size of each subsidy which just exhausts the agency budget. In this way, cost-equivalent subsidies can be calculated and the concomitant benefits, in terms of value added or employment, can be compared and ranked.

From (18) the cost of capital subsidy of r^* can be equated to the size of the budget, B:

$$
\begin{aligned}
(41)\quad & \text{Cost of a capital subsidy} \\
&= -r_0P_kK_0N_0(1 + N^*)r^* = B
\end{aligned}
$$

or from (18) and noting that $-r_0P_kK_0 = -(1-\alpha)P_0X_0$, we obtain:

$$
(42)\quad \left[\frac{\eta(\sigma+\epsilon_L) - \epsilon_L\alpha(\sigma+\eta)}{\sigma(1-\alpha) + \epsilon_L - \alpha\eta}\right](r^*)^2 + (r^*) + \frac{B}{(1-\alpha)P_0X_0N_0} = 0.
$$

The solution of the quadratic (42) determines the amount of capital of subsidy which exhausts the budget B:

$$
(43)\quad r^* = \left[-1 \pm \left(\frac{1 - 4B[\eta(\sigma-\epsilon_L) - \epsilon_L\alpha(\sigma+\eta)]}{[1-\alpha]P_0X_0N_0[\sigma(1-\alpha) + \epsilon_L - \alpha\eta]}\right)^{\frac{1}{2}}\right] \cdot \frac{(\sigma[1-\alpha] + \epsilon_L - \alpha\eta)}{2[\eta(\sigma+\epsilon_L) - \epsilon_L\alpha(\sigma+\eta)]}.
$$

Similarly for a wage subsidy of t percent, the costs are found from (33) which can be equated to B so as to exhaust the budget:

$$
\begin{aligned}
(44)\quad & \text{Cost of a wage subsidy} \\
&= \frac{t}{1-t}w_0N_0L_0(1+w^*+N^*+L^*) = B.
\end{aligned}
$$

Solving (44) using (33), and since $W_0N_0L_0 = \alpha P_0X_0N_0$ determines the largest percentage wage subsidy that can be offered consistent with the agency budget,

$$
(45)\quad t = \left\{-(\alpha P_0X_0N_0+B) \pm \left[(\alpha P_0X_0N_0+B)^2 + \frac{4B(\alpha P_0X_0N_0[\epsilon_L+1][\sigma(1-\alpha)-\alpha\eta]}{\sigma(1-\alpha)+\epsilon_L-\alpha\eta} - 1)\right]^{\frac{1}{2}}\right\}\left[2\alpha P_0X_0N_0\left(\frac{[\epsilon_L+1][\sigma(1-\alpha)-\alpha\eta]}{\sigma[1-\alpha]+\epsilon_L-\alpha\eta} - 1\right)\right]^{-1}.
$$

Finally, for a price subsidy,

$$
(46)\quad \text{Cost of a price subsidy} = \frac{b}{1+b}P_0N_0X_0(1+P^*+N^*+X^*) = B.
$$

Substitution of (40) determines the budget exhausting price subsidy:

$$
(47)\quad b = \left\{-(P_0X_0N_0 - B) \pm \left[(P_0X_0N_0 - B)^2 + \frac{4B(P_0X_0N_0[\eta+1][\sigma(1-\alpha) - \epsilon_L])}{\sigma(1-\alpha) + \epsilon_L - \alpha\eta}\right]^{\frac{1}{2}}\right\}\left[2P_0X_0N_0\frac{(\eta+1)(\sigma[1-\alpha] - \epsilon_L)}{\sigma(1-\alpha) + \epsilon_L - \alpha\eta}\right]^{-1}.
$$

It remains only to substitute the cost-equivalent subsidies into the expressions corresponding to the additional benefits (employment or value added) in order to derive cost-equivalent incremental benefits. Resultant expressions can be compared and ranked, yielding a cost-effective preference ordering. This is easily accomplished for a given set of region and industry parameters by substituting the numerical solutions found from (43), (45), and (47) for r^*, t, and b respectively into the benefits expressions (additional value added and employment) calculated under each subsidy scheme.

The purpose of this discussion has been to develop a framework which will enable subsidy planners to calculate the most cost-effective subsidy to employ in a given region for a given industry. Several variants of this approach are also possible. For example, a knowledge of given industry and regional parameters would enable planners to calculate the expenditure size necessary to achieve a predetermined increment in value added or employment under each subsidy scheme. For a given expenditure, region, and subsidy, one can derive a benefit stream in terms of industry parameters and from them determine the most favorable candidate industries which would lead to the greatest incremental benefit stream. Similarly, for a given budget, industry, and subsidy tool, the regional parameters which produce maximum incremental benefits can be calculated and thus the most favorable region identified.

The primary use to which cost-equivalent incremental benefits calculation can be put is to identify a preferred subsidy program for a specific region and specific industry. In Tables 1 and 2, calculations for hypothetical values of the parameters are illustrated and the value of the resultant incremental benefits is indicated. The value of incremental benefits is expressed in terms of initial values so that not only relative rankings but absolute rankings are possible. Thus, from Table 2, as the industry demand becomes more elastic, the superiority of a wage subsidy over a price subsidy in generating additional employment diminishes.

The approach illustrated in Tables 1 and 2 suggests that a sensitivity analysis whereby relative and absolute rankings of alternative schemes are calculated will be productive in providing insight for policy guidance. Depressed regions and candidate industries can be characterized in terms of likely ranges of values for the region and industry specific parameters. Calculations similar to those illustrated in Tables 1 and 2 can be undertaken for all permutations of the parameters over these relevant ranges. The sensitivity of relative and absolute rankings as the iterations proceed then indicates preference rankings, loss from using an inefficient subsidy, and general sensitivity of rankings to the parameters. This type of analysis would be useful in assessing the loss of selecting one blanket subsidy to be applied in all regions for all industries versus tailoring the most cost-effective subsidy to each specific region-industry.

Table 1. **Goal: incremental value added**

	Subsidy Programs		
	Capital	Wage	Price
*Hypothetical Parameter Values**			
Set I	0	0	$0.012\, X_0N_0P_0$
Set II	$0.0086\, N_0X_0P_0$	$0.004\, N_0X_0P_0$	$0.016\, N_0X_0P_0$

* Hypothetical Parameter Values:

	σ	η	α	${}_eL$	$B/P_0X_0N_0$
Set I	1.0	−1.0	0.5	1.0	0.01
Set II	1.0	−2.0	0.5	1.0	0.01

Table 2. **Goal: incremental employment**

	Subsidy Programs		
	Capital	Wage	Price
*Hypothetical Parameter Values**			
Set I	0	$0.010\, N_0L_0$	$0.006\, N_0L_0$
Set II	$0.0043\, N_0L_0$	$0.012\, N_0L_0$	$0.008\, N_0L_0$

* Hypothetical Parameter Values:

	σ	η	α	${}_eL$	$B/P_0X_0N_0$
Set I	1.0	−1.0	0.5	1.0	0.01
Set II	1.0	−2.0	0.5	1.0	0.01

Observations

As noted earlier, the arrays shown in Tables 1 and 2 are only intended to be illustrative of the type of empirical analysis which will be undertaken as the study progresses. A full simulation of combinations of the meaningful parametric values will provide the results necessary to delineate the relative impact of alternative subsidy schemes given specific regional/industry combinations. A full test of the model should therefore permit not only an overall assessment of different subsidy programs in light of the stated objectives of EDA, but also a specification of the optimal subsidy which should be used given specific regions of interest to EDA and alternative candidate industries seeking to locate in these regions.

The model in its present form clearly has some limiting assumptions which, it can be agreed, restrict its relevance to dealing with underdeveloped areas. In particular, the assumption of a completely elastic supply of capital does not typify the situation existing in rural America. One refinement of the model therefore will be concerned with assessing the factors which influence the supply of capital (both in terms of its cost and its availability) and incorporate the findings into the model in terms of alternative values of ϵ_K.

The approach taken in the total study effort is to preserve a balance between the analytic framework, the availability of data and problems of estimation, and the policy considerations facing EDA. In conclusion, it should be stated that the model has been developed within the basic premise that the overall purposes of the study would not be met if this balance was lost. This analytic framework, it is felt, provides the necessary analytic rigor to prevent government policy makers from having to make decisions on subsidy tools on a largely *ad hoc* basis and yet allows the explicit consideration of particular problems, issues, and constraints of the agency whose delivery mechanisms are being examined. We would argue that this balanced approach to examining and assessing the worth of government social program delivery systems is the exception rather than the rule.

Post-Script

Since the time of delivery of this paper we have successfully incorporated into the theoretical framework an additional parameter designating the regional supply elasticity of capital. Simulations have been performed with this expanded version, identifying the most appropriate subsidy program for the development goals of value added, employment and the additional goals of output and payrolls. The general results for program selection, briefly stated, are to employ wage subsidies in order to generate additional payroll and employment; price subsidies for additional value added; and for output, factor subsidies aimed at the factor in most elastic regional supply. In addition, for each goal-region specification the most appropriate subsidy and industry characteristics have been identified.

References

[1] Borts, G., "Criteria for the Evaluation of Regional Development Programs," *Regional Accounting for Policy Decisions*, Johns Hopkins Press, 1966, pp. 183–218.

[2] Borts, G., and Stein, J., *Economic Growth in a Free Market*, Columbia University Press, 1964.

[3] Hicks, J. R., "Elasticity of Substitution Again," *Oxford Economic Papers*, November 1970.

Financing Agriculture: Demand for and Supply of Farm Capital and Credit*

EMANUEL MELICHAR

IN this paper, I discuss aggregate farm financial relationships and trends and then project a large further increase in farm debt. Along the way, I note some interesting findings bearing on the underlying causes of the debt-increase process—findings that raise questions about the completeness of the popular current assessment of that process. Where my story differs from the standard analysis, I take the liberty of stating the differences boldly—perhaps more boldly than they deserve to be advanced, given deficiencies of the data base and the fact that current econometric work on aggregate postwar farm financial behavior is still in the exploratory stage. But since my projections do not differ significantly from those emanating from the standard analysis, I thought it best to emphasize the analytical differences lest they be overlooked when, as usually happens, the numerical projections attract the limelight.

To whet your appetite for the analysis, therefore, let me momentarily depart from orderly presentation of the subject to look at the main components of the standard analysis of most farm economists and lenders. A statement by Evans on the agricultural finance outlook for 1972, presented at the USDA's National Outlook Conference last February, is representative of this genre:

> More credit will be used this year than any year so far—about 7 per cent more than last year which was also a record . . . it is reasonable to ask, why the increase and for what purpose? Perhaps of most importance is that farmers are basically optimistic. And this year they may be more willing than usual to borrow to become more efficient or to meet higher costs. . . . Capital improvements and farm enlargement . . . will create additional debt. Building and equipping livestock feedlots . . . will require increased financing. . . . Farm operating costs are continually increasing. . . . Money going into livestock, ranch, and feedlot operations in 1972 will likely increase over 1971. . . . Machinery and equipment bought to replace worn-out or obsolete items will cost more than last year. . . . Other expense items will also increase. All of these expense items will call for additional sums of borrowed money. [3, pp. 1–3]

On January 1, 1972, outstanding farm debt (excluding CCC loans) was estimated at $64.6 billion, having risen steadily from a low of $7.6 billion in 1946 and more recently from $27 billion in 1962. The increase of 7 percent expected by Evans in 1972 therefore amounts to $4.5 billion.

Using the model of the farm financial sector on which most of this paper is based, and specifically the particular long-term simulation that is presented here, I find that the increase in debt projected for 1972 is $4.69 billion. This is virtually identical to Evans' projection. So what is my problem?

The standard analysis, as we have seen, attributes the increase in debt mainly to additions to capital assets and increases in land, machinery, and other input prices. To test this hypothesis, I therefore performed a second simulation in which I specified that all real capital stocks remain unchanged at their January 1, 1972 level. The projected increase in debt during 1972 was $4.63 billion. In a third simulation I specified that neither the general price level nor any asset price could change during 1972. The projected increase in debt was $4.20 billion. Finally, in a fourth simulation I specified that neither prices nor real stocks could change. The projected increase in debt was then $4.16 billion.

Thus, while Evans and I agreed on the increase in debt projected for 1972, I can attribute only $530 million of that increase directly to the causal factors he emphasized. An explanation for the other $4.16 billion must await the orderly presentation of the flow-of-funds model to which I now turn.

A Model of Farm Capital and Credit

Formulation of the model has its roots in previous work by Tostlebe, Johnson, and Brake

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* The author gratefully acknowledges helpful discussions with John Penson, Robert Reinsel, and Allen Smith, and assistance from Harriet Holderness, Joan Hosley, and Carol Low in the preparation of the model and this paper. A detailed description of the model and projections presented here is available from the author.

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[2, 5, 8, 13]. When employed as a framework for analysis of past financial behavior, the capital flows that had to be financed are first identified, quantified, and summed. This sum was financed either externally, through increase in debt, or internally from farm cash flow (net income and depreciation allowances). The increase in debt is known, and so the amount of internal financing is computed residually. Insight into the causes of any past changes in outstanding debt can be obtained by noting the course of the total capital flow over time and by observing the behavior of such ratios as the percentage of cash flow devoted to internal financing.

For simulation and projection, some additional steps are necessary. First, equations are developed for the various components of capital flow and are solved to obtain estimated total capital flow under specified conditions. The same is done for the components of cash flow. Another equation specifies the "savings rate," the proportion of cash flow that farmers will allocate toward meeting their capital flow. The amount of internal financing is then computed. Finally, the difference between that amount and the total capital flow is the increase in debt that will occur.

For the farm finance insights that we seek, we must go through this formulation step-by-step, at each point examining the historical data, the equation developed for the model, and the projected data employed in or obtained from the specific simulation, covering 1972–79, on which this paper focuses. Eight charts that illustrate the historical and projected data form an integral part of this presentation. A unique feature of these charts is that all series on all the charts are plotted on the same ratio scale; thus equal slopes anywhere represent the same annual percentage rate of change, and equal vertical distances indicate the same total percentage change.

Capital flow.—The capital flow to be financed consists of expenditures for new machinery, buildings, and land improvements; changes in holdings of livestock, stored crops, and financial assets; and an annual capital requirement associated with the largest farm input, land. Except the last item, these are straight-forward concepts for which USDA estimates are published. But the annual land capital requirement presents conceptual as well as data problems.

Real estate transfers.—To start with, I think that other workers who have recently added up farm capital flows, also with the goal of estimating credit demands, have erred conceptually, given that particular goal, in their choice of the measure of the annual land capital requirement. One sets it equal to the change in book value of the land that is transferred [1, 2]. Others use the change in the total value of all land [6, 10].

But I reason as follows. First, the capital flow to be financed is associated with transfers; if perchance no land is transferred in a given year, there is no capital requirement to be financed that year. On the other hand, if some land is transferred, there may be a positive capital requirement even if the total value of all land remained unchanged or even decreased. Thus the financing requirement does not correspond to the capital appreciation, if any, that may have occurred.

Second, there is no capital requirement to be financed when land is inherited rather than purchased. And for the farming sector as a whole, there is no new financing requirement to the extent of existing outstanding debt on the property transferred, or to the extent that land is sold by persons who continue to be farm operators. Thus the financing requirement does not correspond to the change, if any, in book value. (The book value and capital gain concepts are simply variants of the same theme; one defers recognition of appreciation until the year of transfer, while the other records it as it occurs.)

With these negative observations in mind, I can derive a positive statement of the annual financing requirement associated with farm transfers: it is the amount of funds withdrawn from the farming sector by sellers who leave the farming sector or who are nonfarm heirs.

My rough estimate of this series is shown in Figure 1. For 1965–71, it corresponds to the value of voluntary and estate transfers less adjustments for existing debt and for sales by persons who continue to farm. For 1950–64, the value of transfers in this calculation is approximated by the product of the total value of farm real estate, the percentage of farms transferred, and an adjustment factor to reflect that the average parcel transferred differs from the average farm in size and per-acre value.

As Figure 1 illustrates, an upward trend in the annual capital flow required by transfers reflects a similar trend in the total value of farm real estate, while short-term fluctuations

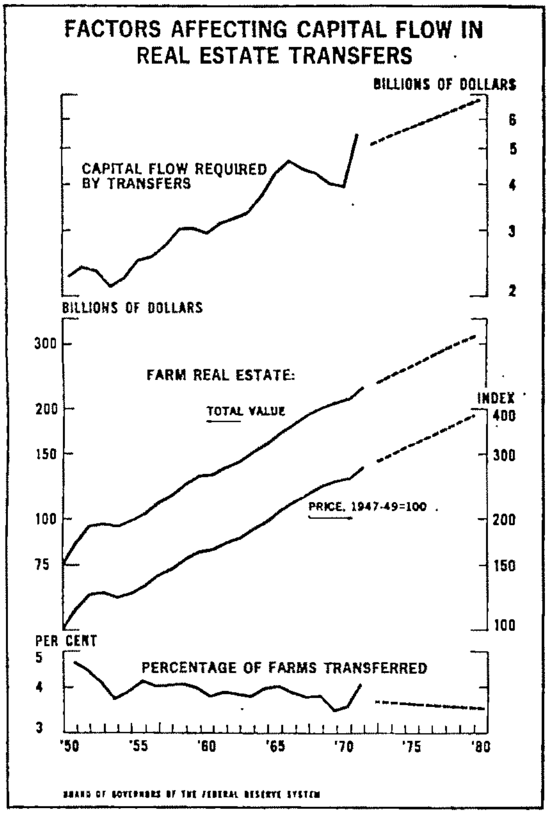


Figure 1

in the annual flow reflect variations in the percentage of farms transferred (land market activity). Furthermore, the rising trend in total value of real estate reflects mainly the trend in land prices, as the real stock has risen by only 10 percent since 1950, very little of this in the last few years (Table 1).

The process of projecting the annual capital flow required by transfers employs the above sequence in reverse. The key element is the land price projection, to be discussed below. Real stock is projected as unchanged from the January 1972 level, and this value times the projected price yields the projected total value series. The projected percentage of farms transferred is an extrapolation of the 1950–72 trend. The projected annual capital flow is the product of this ratio, the total value, and the three adjustment factors listed above.

Note that in this model no attempt has been made to develop equations that would incorporate factors causing the significant short-term variations in variables such as land market activity. Consequently, the model can project only the longer-term trend.

Price of land.—Real estate constitutes over two-thirds of total capital stock (Table 2), and the annual capital flow associated with real estate transfers usually represents about two-fifths of total capital flow (Table 3). Thus the projected land price greatly influences the projected total capital stock and flow. In these circumstances, considerable importance attaches to development of a structural equation for the price of land. (All asset prices in the model are measured as the implicit price deflators calculated from data in the USDA's *Balance Sheet of the Farming Sector.*) Unfortunately, a large number of possible explanatory variables with strong postwar trends are highly correlated with the national average land price. For instance, Reinsel obtains an R^2 of .99 using population and the money supply (M_1) [11]. As he notes, what usually passes for great success is readily achieved with little assurance that any real knowledge has been gained.

In my land price equation, I use the three variables shown in Figure 2. Of these, general price level and number of farms—the latter intended to reflect the pace of land market and farm enlargement activity—contribute most of the R^2 of .98. The index of crop production per acre, intended to represent the intrinsic value of farmland, is relatively uninfluential in this equation.

To solve this equation for the price of land during 1972–80, values of the explanatory variables must first be projected. For crop production per acre, I extrapolate the 1950–72 linear trend, which has this index rising by about 1.7 per cent annually over the projection period. For farm numbers, I extrapolate the 1950–72 double-log trend, which results in numbers falling by about 2.5 per cent yearly.

General price index.—Choosing an appropriate projection of the general price level—represented by the implicit price deflator for private GNP—is not only more difficult, but also more important in that the choice affects all incomes, wages, and asset prices in the model. On average, this GNP deflator rose by 2.1 per cent yearly during 1950–72. If the periods of war-related inflation and subsequent price controls at each extreme of this span are omitted, the average rate of increase during the remaining years (1953–68) was 1.7 percent. But much of this period was characterized by a degree of underutilization of labor and other resources which, it appears, is not likely to be

Table 1. Average annual percentage changes in farm capital stocks and prices

Stock	1950–54	1955–59	1960–64	1965–69	1970–71	Projection 1975–79
			Real stocks			
Total	1.4	.1	.2	.9	.5	.4
Real estate	.8	.4	.4	.2	.2	.0
Operators' dwellings	−2.3	−1.1	−2.3	−2.9	−3.5	−2.8
Service buildings	−2.3	−1.0	−2.3	−2.8	−2.6	−2.7
Machinery	6.6	− .3	− .5	1.4	.1	.8
Livestock	2.2	− .1	1.4	.8	2.6	.9
Stored crops	2.1	.7	− .4	5.8	2.2	2.0
Currency	−3.6	−3.9	−1.9	− .9	−3.2	−2.4
Demand deposits	−1.1	−2.7	−2.6	− .9	−3.1	−2.0
Time deposits	1.7	1.4	3.4	5.2	2.9	3.3
U.S. savings bonds	−1.0	−2.5	−3.0	−4.1	−5.7	−3.9
			Implicit price deflators			
Total	3.1	4.5	3.1	4.4	4.9	3.5
Real estate	4.6	5.4	3.9	5.0	4.9	4.1
Machinery	2.0	4.5	2.2	3.7	6.8	3.8
Livestock	−4.1	6.3	−2.2	9.4	5.3	2.4
Stored crops	2.7	−4.1	3.9	−1.0	1.9	.1
Financial assets	2.1	1.5	1.4	2.7	5.5	2.2
			Stocks			
Total	4.5	4.5	3.3	5.3	5.4	4.0
Real estate	5.5	5.8	4.3	5.1	5.1	4.1
Machinery	8.9	4.1	1.7	5.2	6.9	4.6
Livestock	2.5	6.3	−1.1	10.3	8.0	3.4
Stored crops	4.9	−3.7	3.5	3.5	4.2	2.1
Currency	2.1	−2.8	− .6	1.8	2.1	− .5
Demand deposits	.9	−1.4	−1.4	1.7	2.1	− .1
Time deposits	3.8	3.0	4.9	8.1	3.3	5.6
U.S. savings bonds	1.0	−1.2	−1.9	−2.1	−1.9	−2.2

tolerated in this decade. So a higher rate of inflation might be projected as a consequence of running a more fully-employed economy—not, however, approaching the rates over 4 percent experienced during 1969–71, which proved equally unacceptable. After weighing these factors, I chose to use 2.5 percent in the projection being described. Later I will also report briefly on results from use of other rates of general price inflation.

Machinery purchases.—Purchases of new machinery are the other major capital flow, accounting for another two-fifths of the total flow. The record of purchases since 1950, shown in Figure 3, seems cyclical, and indeed purchases exhibit several long cycles in this century. The upward trend in the value of the machinery stock on farms, fairly sharp in recent years, is well-known, but few persons seem aware that virtually all the rise in value since 1955 has occurred through price increases. (Real stock data for the last decade were revised downward this year, eliminating much of the already small gains that had previously been shown for the mid-1960's.) What this means is that large annual purchases have largely just served to replace worn-out or obsolete machinery. Comparison of USDA expendi-

Table 2. Percentage composition of farm capital stock

Stock	1950	1955	1960	1965	1970	1972	Projection 1975	Projection 1980
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Real estate	61.8	64.6	68.6	72.2	71.7	71.2	73.0	73.5
Machinery	10.0	12.2	12.0	11.1	11.0	11.3	12.1	12.5
Livestock	10.6	7.4	8.0	6.4	8.1	8.5	6.8	6.6
Stored crops	6.2	6.3	4.1	4.1	3.8	3.7	3.2	2.9
Currency	2.1	1.5	1.0	.8	.7	.7	.6	.5
Demand deposits	3.7	3.1	2.3	1.8	1.5	1.4	1.3	1.1
Time deposits	1.7	1.7	1.5	1.7	1.9	2.0	2.1	2.3
U.S. savings bonds	3.9	3.3	2.5	1.9	1.3	1.1	1.0	.7

Table 3. Percentage composition of farm capital flow

Capital flow	1950–54	1955–59	1960–64	1965–69	1970–71	Projection 1975–79
Total	100.0	100.0	100.0	100.0	100.0	100.0
Real estate transfers	30.1	39.1	41.3	39.2	37.6	39.4
Capital expenditures:						
Machinery	40.7	39.4	40.2	42.5	41.5	45.8
Operators' dwellings	8.4	7.4	6.0	4.5	3.9	3.5
Service buildings	12.0	12.1	10.0	7.2	7.0	5.8
Additions to inventory:						
Livestock	6.3	1.3	3.2	1.0	4.8	1.5
Stored crops	1.1	2.4	– .5	2.2	.5	1.5
Additions to financial assets:						
Currency	– .7	– .9	– .2	.3	.3	– .1
Demand deposits	.5	–1.0	– .8	.7	.8	.0
Time deposits	1.1	1.1	2.0	3.2	3.9	3.0
U.S. savings bonds	.7	– .9	–1.1	– .8	– .3	– .5

ture and depreciation-allowance data confirms this view.

Projected machinery purchases are the sum of the spending necessary to cover depreciation allowances and to achieve any projected increase in real stock. Annual depreciation allowances since 1950 have varied only between 13.3 and 15.6 percent of the January 1 stock. The average ratio (14.4 percent) is used to project this item. The second component is based on a structural equation for the real stock, discussed below. Both components are valued at machinery prices that are projected to advance from the 1972 level at the 1953–68 average annual rate of 3.1 percent, adjusted upward to 3.8 percent to reflect that, as already noted, more general price inflation is projected than was experienced in 1953–68.

Real machinery stock.—Real machinery stock rose very rapidly from the end of World War II to the mid-1950's, under the influence of factors that apparently differed markedly from those affecting the stock after 1954. At any rate, the three factors shown in Figure 4—the acreage of crops harvested, ratio of machinery prices to farm wage rates, and the real machinery purchasing power of farmers' cash flow—explain much of the minor movement that occurred in the real machinery stock since 1954

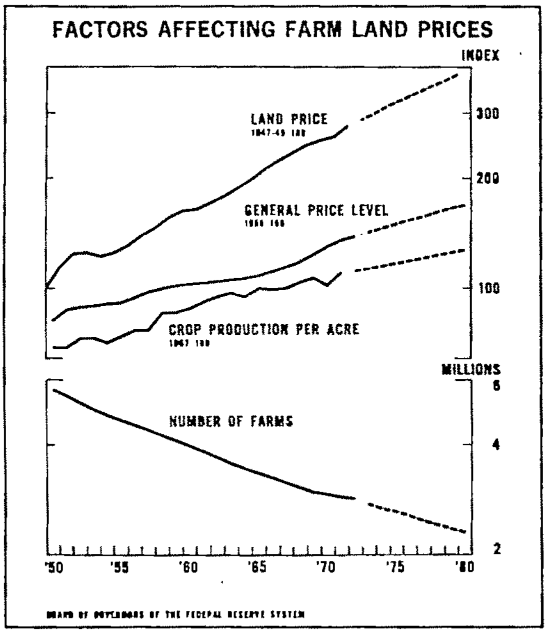


Figure 2

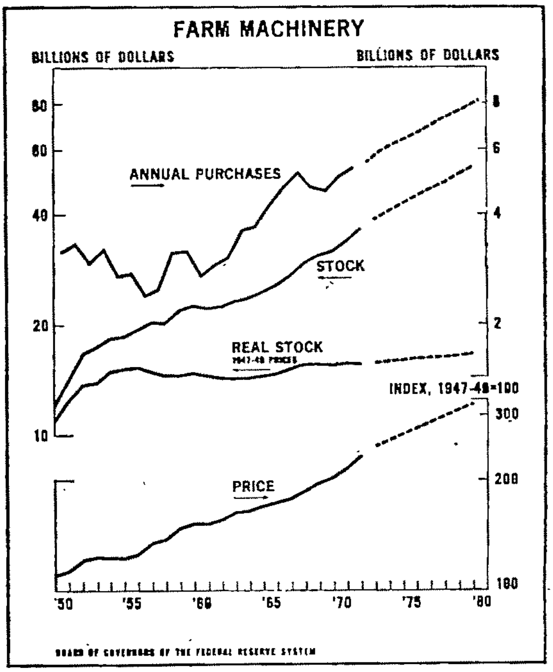
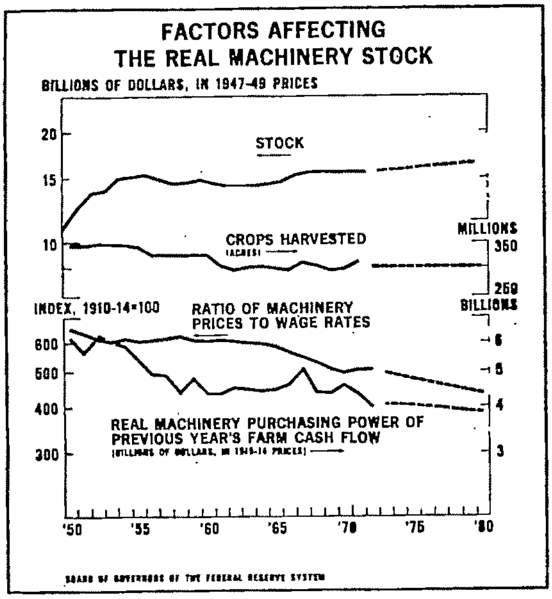


Figure 3



BOARD OF GOVERNORS OF THE FEDERAL RESERVE SYSTEM

Figure 4

(all significant at the 1 percent level, $R^2=.91$), but not the behavior in earlier postwar years. The stock declined in the late 1950's when crop acreage fell and machinery prices rose faster than cash flow. Then in the mid-1960's the stock rose when crop acreage stabilized and wage rates and cash flow began to rise faster than machinery prices. Additions to the stock stopped when the latter relationships were reversed in the late 1960's.

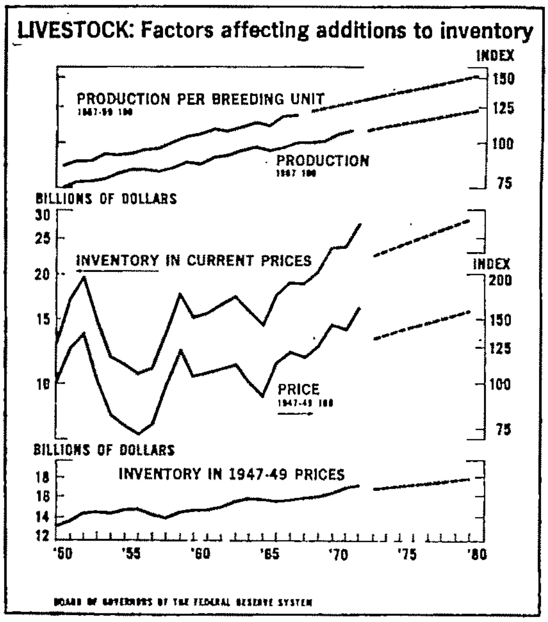
To solve the real machinery stock equation, crop acreage harvested is projected at the average level of the past 10 years. Wage rates and net income per farm are obtained by projecting that farm laborers and operators will participate to an average extent in an annual increase of 3.25 percent projected for national real per capita income. Thus after adjustment for the projected rate of general price inflation, both farm wage rates and net income per farm are projected to rise by nearly 6 percent annually. Total net farm income, the largest component of farm cash flow, is obtained as the product of per farm income and projected farm numbers. The remaining components are the projected depreciation allowances for machinery, buildings, and land improvements. Given the resulting values for the two ratios used in the equation, the real machinery stock rises by about 0.8 percent annually during the projection period.

Additions to livestock inventory.—Annual capital expenditure for livestock consists of the value of the physical change in the livestock inventory during the year. The average relative amount of this capital flow (Table 3) may appear surprisingly small to those familiar with the trend in physical livestock production. Part of the explanation appears in the top portion of Figure 5. A significant portion of the livestock inventory consists of breeding units, and output per breeding unit (a USDA series discontinued in 1968) has been rising somewhat faster than total output.

Furthermore, as the center portion of Figure 5 indicates, the sharp rise in value of the livestock inventory since 1964 has been largely a revaluation that does not entail a capital flow. Two livestock cycles are evident in both the price and real stock series charted, and 1972 finds us in the third rising phase since 1950. Both series are now substantially above their 1950–72 trend lines.

Projected changes in livestock inventories are obtained as follows. First, the real stock and the price deflator are projected by extrapolating their 1950–72 trends, which were, respectively, 0.9 and 1.7 percent a year. The rate of price increase is adjusted upward to 2.4 percent. Each year's change in real stock is then valued at the price projected for that year.

The resulting annual flow is in the $200 to $250 million range. Given the cyclical nature



BOARD OF GOVERNORS OF THE FEDERAL RESERVE SYSTEM

Figure 5

of this series, actual annual flows will fluctuate considerably around such a trend projection. During 1950–71, the annual flow ranged between $1,107 million and $−345 million.

Additions to the stored crop inventory.—A similar procedure is used to project changes in the inventory of stored crops, and as it happens the projected annual flow lies in the same range. In contrast to the rising livestock price trend, however, such trend as could be discerned in stored crop prices during 1950–72 was slightly downward. But the real stock averaged a 2.0 percent annual gain. Annual flows during 1950–72 ranged between $1,169 million and $−782 million.

Additions to financial assets.—Financial assets properly included in this model are those that constitute the working capital or readily-available secondary reserves for farm operations. Farmers' holdings of currency, demand deposits, and time deposits at commercial banks meet these criteria. Having included time deposits, which have been rising sharply, it seems advisable to include also a close substitute, U. S. savings bonds, holdings of which have been declining.

The price deflator used by the USDA to compute the real stock series for financial assets (as well as to obtain real net farm income) is the index of prices paid for farm family living items. This index rose by 1.5 percent annually during 1953–68; consequently, the projected rate of increase is 2.3 percent a year.

In real terms, the average annual rate of change in farmers' financial assets over 1950–71 was as follows: currency, −2.7 percent; demand deposits, −2.2 percent; and time deposits, 3.3 percent. The real stock of U. S. savings bonds developed a consistent downtrend after 1960, at an annual average rate of −4.6 percent. These rates are used in the real stock projections.

Upon combination of the real and price trends, financial assets are projected to change at these annual rates: currency, −0.5 percent; demand deposits, no change; time deposits, 5.6 percent; and U. S. savings bonds, −2.4 percent. The projected combined annual capital flow to achieve these changes is $247 million in 1972 and rises to $456 million by 1980.

The combined projected flow for financial assets and inventory additions is shown in Figure 6. Though it is rising relatively fast, this sum still averages only 6 to 7 percent of the total capital flow to be financed. One may be concerned that these stocks of working capital have been measured on January 1, whereas the peak in farm production activity in most areas occurs during the summer. However, I have shown elsewhere [9, pp. 146–148] that farm operating expenses with large seasonal components increased by only 3.3 percent annually during 1956–68, and that the seasonality in bank and PCA operating loans has fallen drastically.

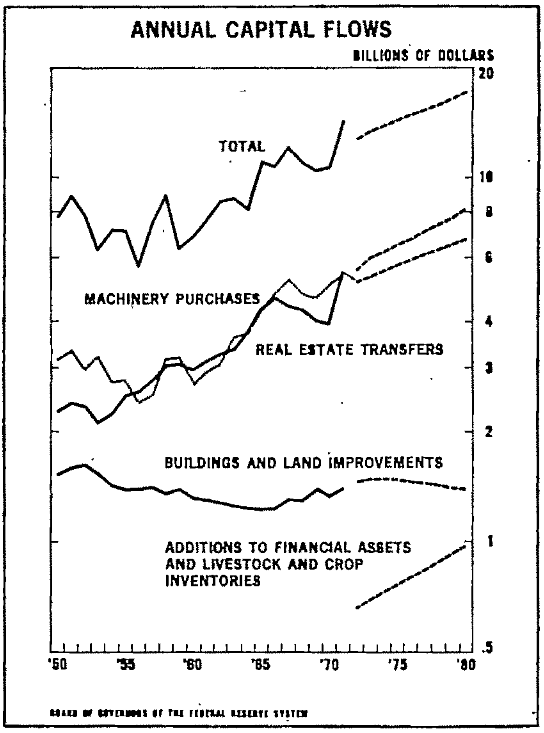


Figure 6

Expenditures for buildings and land improvements.—Real stocks of farm operator dwellings and of service buildings and land improvements have been decreasing, partly as farmsteads have moved out of the farming sector, and otherwise because expenditures since the mid-1950's have been lower than capital consumption. Rates of decline were greater in the last decade than in the 1950's. Average annual rates of the last 10 years are used for the projections: −3.2 percent for operators' dwellings and −3.0 percent for service buildings and land improvements.

After projection of these real stock series, depreciation allowances are projected by applying the annual depreciation rates that the USDA presently plans to employ, which are 4.67 percent for dwellings and 7.22 percent for service buildings. To complete the projection of capital consumption, accidental damage is projected at the average annual rate (0.69 percent) experienced since 1950.

Annual expenditures are then projected as the amounts required to make up for the capital consumption as necessary to hit the annual stock figure projected for the end of each year, plus an adjustment for the buildings on land removed from the farming sector. The total annual expenditure is shown in Figure 6.

The expenditure and capital consumption series are all valued according to indexes of construction costs, which during 1953–68 rose at average annual rates of 1.8 percent for dwellings and 1.7 percent for service buildings. After adjustment to reflect the higher rate of general price inflation projected, these price series are projected to advance at average annual rates of 2.5 and 2.4 percent, respectively.

Total capital flow.—The sum of all these capital flows—the total annual amounts that had to be financed—is shown in Figure 6. Those who judge the amount of financing needed by looking at the trend in total assets or in outstanding debt say that financing needs have been going up, up, and up. Not so. For instance, there was hardly any change for six straight years recently, 1965–70. And in the early 1950's the trend was down. But in some years, such as 1965 and 1971, a boom in machinery buying or a spurt in land market activity can cause the capital flow to be financed to rise much faster, percentagewise, than the value of the stock. The point is that the two are only loosely related—as the preceding item-by-item tour should have made clear—and to continue our analysis of farm financial behavior, it is the flow series that we need.

After hitting $12.0 billion in 1967, the capital flow to be financed fell off the next three years, then broke out to a new high of $14.4 billion in 1971 as real estate transfers and additions to livestock and stored crop inventories were all unusually high. The projected values, the sum of all component projections, begin at $12.8 billion in 1972 and climb to $17.3 billion by 1980, which is an average annual increase on the order of 3.7 percent.

Knowing the past capital flow opens up a whole new world of analysis. To begin with, we can ask how burdensome the capital flow has been in relation to the stream of funds received after current operating expenses have been paid—the farm cash flow.

Cash flow.—Farm cash flow and how it is projected have already been discussed in the section on machinery purchases, but an additional word about the concept may be in order.

As just noted, gross farm income less current farm operating expenses equals the farm cash flow. USDA accounts divide the cash flow into two further components: net farm income and capital consumption allowances. The latter sum represents the amount that, if spent on new machinery and buildings, would exactly compensate for the wear, obsolescence, and damage during the year, as estimated from schedules reflecting average experience with such matters.

But in any given year, the capital consumption allowances and the spending on buildings and machinery are different—related, certainly, but not identical. The allowances and net income are a commingled and indistinguishable income stream. Recipients of the cash flow can spend these funds as they wish.

This point is important because the part labelled "capital consumption allowances" is now a substantial 28 percent of the farm cash flow—$7.2 billion out of $24.6 billion cash flow in 1971 (Table 4). Furthermore, in contrast to the meandering course of net farm income, the allowances have risen steadily mainly due to the rising value of the machinery stock, but during the last decade also because the USDA was shifting to much higher depreciation rates for buildings. Projected annual increases average 3.4 percent for allowances, 2.9 percent for net farm income, and 3.0 percent for total farm cash flow (Fig. 7).

The relative capital financing burden.—Since 1965 the capital flow has on average been half as large as the cash flow (Table 5). At this ratio, the relative burden has shifted upward significantly from the 1950–64 average of 0.43. The first year over 0.50 during the period studied was 1965, and 1971 was the highest year at 0.59. The projected relative burden rises slowly from 0.50 in 1972 to 0.52 in 1979. If the farming sector were to allocate this proportion of cash flow toward financing the capital flow, there would be no increase in outstanding debt.

Internal financing.—The second significant analytical gain from knowing the past annual capital flow is that the amount of past internal financing can then be computed merely by subtracting the known increases in debt from the annual capital flows. The resulting in-

Table 4. Percentage composition of farm cash flow

Farm cash flow	1950–54	1955–59	1960–64	1965–69	1970–71	Projection 1975–79
Total	100.0	100.0	100.0	100.0	100.0	100.0
Net farm income	82.0	76.4	75.7	74.2	71.9	71.1
Capital consumption allowances	18.0	23.6	24.3	25.8	28.1	28.9
Machinery	12.9	17.1	17.3	18.1	20.1	22.4
Operators' dwellings	1.9	2.5	2.6	2.8	3.1	2.6
Service buildings	2.2	3.0	3.4	3.9	4.0	3.3
Accidental damage	.9	1.0	1.0	1.0	.9	.7

ternal financing series is shown in Figure 7. The figure illustrates well how the proportion of capital flow financed internally has dropped from around 88 percent in the early 1950's to less than 65 percent in recent years (Table 5).

Savings rate.—Greater analytical significance, however, attaches to the ratio between internal financing and cash flow, for this represents the percentage of its flow of spendable funds that the farming sector has in fact allocated toward meeting the capital flow. This ratio, which for convenience I will call the "savings rate," stood at a steady 37 percent in the early 1950's, but over the next ten years moved down into the low thirties, where it has on average remained (Table 5). The average for the last ten years was 31.4 percent.

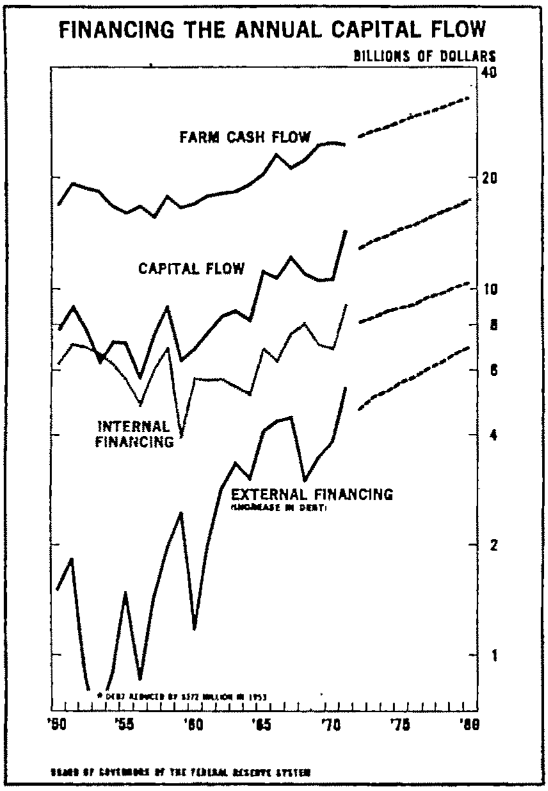


Figure 7

The record of these analytical ratios is worth reiterating for the insight it gives into debt expansion of the past two decades. In the early 1950's, when capital flow averaged 42 percent of cash flow, the savings rate was 37 percent, and thus 88 percent (.37/.42) of the capital flow was financed internally. But in the late 1960's, by which time the capital flow had *increased* to 50 percent of cash flow, the savings rate had *dropped* to 32 percent so that only 65 percent (.32/.50) of the capital flow was financed internally. Thus the move toward greater external financing had two aspects rather than one, and the shift in the savings rate deserves as much recognition and study as the shift in the capital flow burden. Similarly, the prognosis for the amount of internal financing needs to be a part of any speculation about the future course of farm debt just as much as the prognosis for capital spending and other capital flows. And the reasons for and possible consequences of a long-term shortfall in internal financing beg for the attention of analysts.

Incidentially, this clarifies why, in the little paradox I initially posed, the projected increase in debt for 1972 was only marginally dependent on an increase in capital flow. The present annual gap between internal financing and the capital flow is so large that any conceivable one-year shift in internal financing is not going to come anywhere near closing it. So one does not need to project a higher capital flow next year in order to project a sizable increase in debt. One can do so even while expecting the same or lower capital flow!

Projected financing.—Turning from the past to the future, and having already projected farm cash flow, we are ready to calculate projected internal financing. For this, a long-term projection of the savings rate is needed. Many possible influences on this variable come to mind: the state of confidence in long-term farm

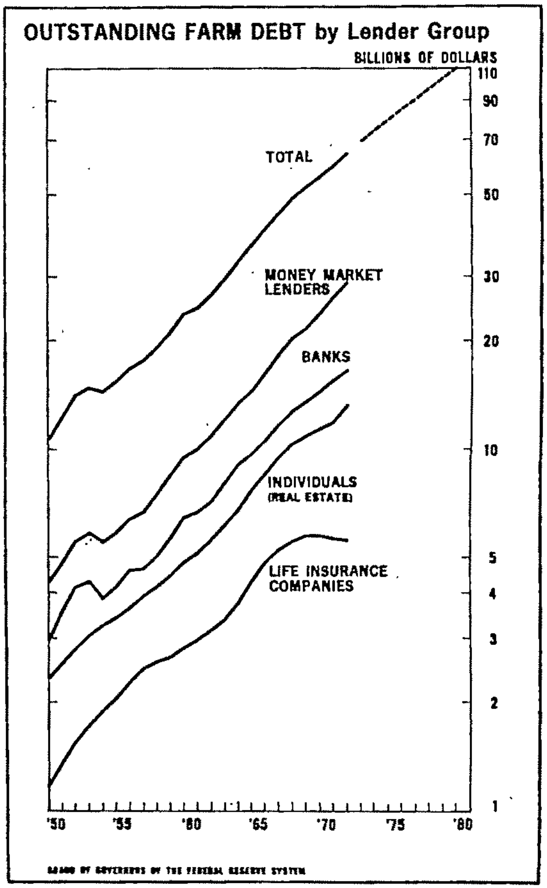
Table 5. Analysis of farm financial behavior

Analytical ratio	1950–54	1955–59	1960–64	1965–69	1970–71	Projection 1975–79
Ratio of capital flow to cash flow	.42	.43	.44	.50	.51	.52
Proportion of cash flow allocated to financing capital flow (savings rate)	.37	.33	.30	.32	.32	.31
Percentage of capital flow financed—						
Internally (from cash flow)	88	77	69	65	63	61
Externally (by increase in debt)	12	23	31	35	37	39
Average annual growth rate of—						
Capital stock	4.5	4.5	3.3	5.3	5.4	4.0
Outstanding debt	7.5	8.9	8.8	9.0	8.0	6.7
Ratio of:						
Debt to capital stock (end of period)	.10	.12	.16	.19	.20	.25
Increase in debt to increase in stock	.16	.21	.37	.29	.29	.40

income prospects, appreciation (or lack thereof) of their farm and nonfarm investments, earnings available on nonfarm credit or equity instruments, relative desire to upgrade consumption levels, number of farmers' progeny in college, and cost and availability of credit. The list could go on. As with the projected inflation rate, it seems best to assume one specific savings rate and then vary it for alternative projections. As the savings rate averaged about 31 percent in each of the last two five-year periods, it is projected to continue at this level. The product of this rate and the projected cash flow yields the projected internal financing (Fig. 7). When this internal financing is subtracted from the projected capital flow, the projected annual increases in debt are obtained, as also shown in the figure. They approach the $7 billion mark by 1980. During the latter 1970's, this projection indicates that 61 percent of the capital flow is financed internally, and 39 percent by increasing debt (Table 5).

Outstanding debt.—Annual increases in debt, past and projected, accumulate into the outstanding debt shown in Figure 8. Debt reaches $110 billion in January 1980, almost exactly doubling during the present decade. But outstanding debt grows at an annual rate of only 6.7 percent during the latter part of the projection span, which is significantly less than postwar experience so far (Table 5). The debt/asset ratio advances further to .25 by 1980, and the ratio of projected increases in debt to projected increases in the value of assets is .40 and rising, indicating that the debt/asset ratio in this projection is considerably far from achieving stability.

Supply of credit.—In this model considerations relating to the cost and availability of credit are subsumed in the determination of the savings rate. I find this an attractive formulation because it keeps one keenly aware that



BOARD OF GOVERNORS OF THE FEDERAL RESERVE SYSTEM

Figure 8

factors affecting the quantity or proportion of internal financing are necessarily also the factors affecting its mirror image, the quantity or proportion of external financing.

I consider this de-emphasis of the credit supply function justified on the grounds that a major lender—the cooperative farm credit system—serving the entire farming sector provides a very elastic supply of funds at a cost tied closely to national money market interest rates. The Farmers Home Administration and the larger farm supply and equipment corporations are also able to raise funds for farm lending in the money market. Together, these "money market lenders," whose outstanding farm loans are shown in Figure 8, are able to respond with almost perfect elasticity to shifts in farm loan demand because agriculture's borrowings represent only a small portion of funds flowing through the money centers. They can offset the effect of changes in the supply of farm loans offered by other lender groups. And the cost of their funds is determined by the interplay of fund demand and supply in the entire economy and thus is only marginally affected by demand changes originating in agriculture.

Other major farm lenders—sellers of farms, life insurance companies, and commercial banks—do have unique loan offer functions that reflect differences in their own sources of funds and other considerations as I have discussed elsewhere [7, pp. 5–6]. Briefly, loans offered by sellers of farms undoubtedly reflect land prices, land market activity, and provisions of tax laws. Farm lending by the life insurance companies appears to be related to their own cash flow (affected in turn by cyclical swings in policy loans and the repayment rate of outstanding loans) and the degree to which they may be temporarily over- or under-committed in commercial lending. For commercial banks, the rate of deposit growth and the relative strength of loan demand from other sectors are probable factors. Each of these lender groups is also influenced by the relative rate of return on its farm lending as compared with other possible loans and investments. Specification of such functions represents a logical future extension of the model. Lins recently completed a model incorporating such detail [6].

Alternative Projections

I began this paper by noting that debt projections for 1972 would be only marginally affected by rather different assumptions about changes in prices and real stocks during that year. Such alternatives can now be examined in more detail.

Deviations from the projected 1980 debt of $110 billion appear most likely to result from price trends that differ from those projected. This could take the form of a sharp change in the price trend for a particular asset such as land or livestock, or the form of an annual rate of general price inflation other than 2.5 percent. The former exercise presents possibilities and combinations without limit and is not attempted here. Results from some of the latter possibilities are reported in Table 6. They indicate that even rather wide changes in the projected rate of inflation do not materially alter the debt projection. However, this exercise indicates that the rising trend in the debt/asset ratio is significantly reduced as the rate of inflation is increased. Even though debt rises faster at higher inflation rates, the value of capital stocks is affected to a greater extent, and therefore the rate at which the farming sector is mortgaging its capital plant is reduced.

The second type of exercise reported in

Table 6. Projections using alternative assumptions regarding prices and real stocks

Projected item	Annual rise in general price level set at:				No change allowed in:			Addendum
	2.5 percent	Zero	1953–68 average (1.7 percent)	1968–72 average (4.1 percent)	Real stocks	Prices	Stocks or prices	
								Value on 1/1/72
Value on January 1, 1980:								
Outstanding debt (billions of dollars)	110	105	108	114	108	100	96	65
Ratio of debt to capital stock	.257	.284	.265	.243	.256	.313	.307	.201
Average per farm (thousands of dollars):								
Capital stock	185	160	177	203	183	139	136	113
Outstanding debt	48	45	47	49	47	43	42	23
								Flow in 1971
Flow in 1980 (billions of dollars):								
Farm cash flow	33.0	27.1	31.1	37.1	32.8	27.0	26.6	24.6
Capital flow	17.3	14.2	16.3	19.5	16.7	12.9	11.9	14.4
Increase in debt	6.9	5.7	6.5	7.9	6.4	4.4	3.5	5.4

Table 6 indicates that a large increase in outstanding debt is very probable over the next few years. Even with no change in stocks or prices, the debt in 1980 is projected at $96 billion, as compared to 1972 debt of $65 billion. Before concluding that a large increase is inevitable, however, we should examine the possibility of a change in the savings rate. In all these projections, internal financing was specified at 31.4 percent of farm cash flow. How would a shift in the savings rate affect the debt projection of $110 billion?

During the projection period, 1972–79, farm cash flow is projected to average $28.8 billion annually. Given the savings rate of 31.4 percent, yearly internal financing averages $9.0 billion ($.314 \times 28.8 = 9.0$). As the average annual projected capital flow is $14.7 billion, an average annual debt increase of $5.7 billion is indicated ($14.7 - 9.0 = 5.7$). Over the eight-year period the total increase in debt is $45.4 billion; thus outstanding debt reaches $110 billion in January 1980.

Going back to the beginning of this sequence, one can see that each increase of one percentage point in the average savings rate for this projection period increases average annual internal financing by $288 million and therefore reduces the average annual increase in debt by the same amount. Thus, for example, a savings rate five percentage points higher represents an additional $1.4 billion in average yearly internal financing. This would reduce the average annual projected increase in debt to $4.3 billion, and outstanding debt in 1980 reaches only $98.5 billion.

What savings rate would stabilize outstanding debt at its January 1972 level? Average annual internal financing would have to rise $5.7 billion. The savings rate would have to be about 20 percentage points higher ($5.700 \div .288 = 20$), putting it at 51 percent. Such a savings rate appears very unlikely. The top savings rates for individual years since 1950 have been 39 percent in 1957–58 and 37 percent in 1950–53, 1955, and 1971. A decrease of about 7 percentage points occurred between the early 1950's and early 1960's (Table 5). If a reverse shift of this magnitude is assumed to occur immediately, projected 1980 debt is reduced by $16 billion. This is a significant effect, particularly when compared to the impact of alternative inflation assumptions and the like, but the move to substantially higher debt over the next few years still seems assured.

Concluding Thoughts on Farm Debt Expansion

What events might bring about an eventual reduction in debt expansion? Since this requires that internal financing get more closely aligned with capital flow, the answer requires a search for possible adjustments in either of these two variables.

First, the amount of real net capital formation supported by the present capital flow is already rather small. Since we do not anticipate that real stocks of machinery and livestock will begin downward trends, there seems little likelihood of a significant negative effect on capital flow from this area.

That leaves, on the capital flow side, the funds being withdrawn from the farming sector, in the course of intergenerational transfers of property. For one thing, an increase in the average level of existing debt on property that is transferred will tend to decrease these withdrawals. We might also wonder whether the rate of farmer retirements and/or the proportion of nonfarm heirs may be lower in the future than it has been over the last two decades.

On the internal financing side, the question boils down to speculation about what the farming sector is doing with the funds that it has not had to save because of the ability to borrow. One possibility is that the sector is enjoying a higher level of consumption by mortgaging its assets. If this is the case, the sector's ability to pursue this course will diminish as the debt/asset ratio rises and as debt service absorbs a higher percentage of gross receipts.

More likely, however, the use of debt rather than internal financing does not stem from that kind of choice, but is instead a necessary consequence of the reorganization of agriculture into larger units. Technological advances keep making larger farms more efficient and profitable than smaller units. The optimum size of farm in most areas has gone beyond the size that represents the wealth that an average American—not to mention an average American farmer—can presently expect to accumulate over his lifetime. As other types of business enterprises in the United States have reached this stage, ownership and management have generally been separated through the sale of equity shares to the public or through takeover by publicly-held firms. Agriculture has largely not yet followed this route. The need to do so has been obviated, at least temporarily, by the ability to raise funds for expansion by increasing debt.

Incidentally, this has allowed farming to remain a single-family enterprise. If the family farmers were unable to increase debt to enlarge farms, so that a sizable gap opened up between unit costs of the typical and of the optimum farm, others with the necessary equity capital or borrowing capability would eventually enter the industry.

Some worry about servicing the higher debt. But if the debt expansion is largely financing the reorganization of farming into larger, more efficient units, presumably the net return from the reorganization is positive—the debt service having been covered from the lower unit costs thereby achieved.

If this view of the major underlying cause of the debt expansion is correct, then it follows that the trend rate of expansion should reflect farm enlargement possibilities and pressures.[1] There remains the ever present possibility, however, that institutional arrangements will be created or revised to allow or to encourage the nonfarm sector to shift to providing funds to the farming sector relatively more through the purchase of equity instruments and relatively less through direct lending or the purchase of credit instruments. For example, fairly recent arrangements already permit a substantial amount of nonfarmer equity investment in cattle operations. Or, Hieronymus points out that some recently created futures contracts in effect permit speculators to furnish equity capital for farm commodities still in the farm production process [4, pp. 130–133]. Further developments like these may eventually alter the financing of agriculture.

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[1] Much of the past analytical comment on increases in capital and debt of individual farms may not have been well founded, however, because it has been based on comparison of per farm averages over time. We have known that the change in such averages is distorted because the farm units disappearing over time are mostly small farms, but we may not have appreciated how big this distortion may really be. In an article that deserves more attention than it appears to have received, Reinsel shows that *two-thirds* of the 1959–64 increase in the average number of acres per farm is a statistical illusion [12]. The published average rose from 302 to 351 acres, or by a sizable 16 percent in five years. But an analysis reveals that the farms still existing in 1964 averaged 335 acres in 1959. On average these farms each purchased or rented an additional 16 acres, raising the 1964 average to 351 acres. Thus the true rise in average size was from 335 to 351 acres, or only 5 percent in 5 years. What a difference from 16 percent! This could well be an indication of the degree to which comparisons of average assets and debt are also distorted.

References

[1] BRAKE, JOHN R., "Capitalizing Agriculture in Coming Years," in *Emerging and Projected Trends Likely to Influence the Structure of Midwest Agriculture, 1970–1985*, ed. John R. Brake, Iowa City, Agricultural Law Center Monograph 11, University of Iowa, June 1970, pp. 28–54.

[2] ———, "Impact of Structural Changes on Capital and Credit Needs," *J. Farm Econ.* 48:1536–1545, Dec. 1966.

[3] EVANS, CARSON P., "Agricultural Finance: Outlook for 1972," paper presented at the National Agricultural Outlook Conference, Feb. 1972.

[4] HIERONYMUS, THOMAS A., *Economics of Futures Trading for Commercial and Personal Profit*, New York, Commodity Research Bureau, Inc., 1971.

[5] JOHNSON, D. GALE, "Agricultural Credit, Capital and Credit Policy in the United States," *Federal Credit Programs*, Englewood Cliffs, New Jersey, Prentice-Hall, 1963, pp. 355–423.

[6] LINS, DAVID A., "An Analysis of Sources and Uses of Funds in the Farm Sector of the United States," unpublished Ph.D. thesis, University of Illinois, 1972.

[7] MELICHAR, EMANUEL, "Aggregate Farm Capital and Credit Flows Since 1950 and Projections to 1980," *Agr. Fin. Rev.* 33:1–7, July 1972.

[8] ———, "The Farm Business Sector in the National Flow of Funds Accounts," in *1970 Proceedings of the Business and Economic Statistics Section*, Washington, D. C., American Statistical Association, 1971, pp. 571–576.

[9] ———, AND RAYMOND J. DOLL, "Capital and Credit Requirements of Agriculture, and Proposals to Increase Availability of Bank Credit," in *Reappraisal of the Federal Reserve Discount Mechanism, II*, Washington, D. C., Board of Governors of the Federal Reserve System, 1971, pp. 107–173.

[10] PENSON, JOHN B., JR., DAVID A. LINS, AND GEORGE D. IRWIN, "Flow of Funds Social Accounts for the Farm Sector," *Am. J. Agr. Econ.* 53:1–7, Feb. 1971.

[11] REINSEL, ROBERT D., "The Aggregate Real Estate Market," forthcoming Ph.D. thesis, Michigan State University.

[12] ———, "Changes in Farm Size," *Farm Real Estate Market Developments*, USDA ERS CD-69, June 1967, pp. 33–39.

[13] TOSTLEBE, ALVIN S., *Capital in Agriculture: Its Formation and Financing Since 1870*, Princeton, Princeton University Press, 1957.

Discussion: JOHN A. HOPKIN, *Texas A & M University*

My comments on the paper by Myers, Rogstad, and Wehner reflect some frustrations arising because I did not have access to the paper until after Christmas and some careless pencilling of equations made the xerox copy which I received impossible to follow in some cases. This, combined with the limitations of my own mathematical maturity, established some communication problems (which have been only partly alleviated by this session).

The problem is more serious, however. The purpose of a model should be to increase precision or to simplify. Much of this paper seems to be caught up in a sort of "Joan Robinson" exercise of taking well understood relationships and expressing them in abstruse forms.

Myers, Rogstad, and Wehner make the assumptions of perfect competition, no economies of scale, and that capital "is available to the industry in unlimited amounts at an invariant price which coincides with the national cost of capital." If all these assumptions were valid, many (but not all) of the current problems in rural development would be corrected.

However, one cannot help but be impressed with the soundness of the conclusions arising from their models. Let me cite three:

(1) A capital subsidy has the effect of lowering the cost of capital relative to labor while a wage subsidy changes relative factor costs in favor of labor. By following through their equations (6) through (11), one "confirms the notion that as capital costs relative to labor costs decline, firms substitute in favor of capital."

(2) "The substitution effect against labor due to a lowering of capital costs must be compensated for by an expansion in total industry output if total employment is to increase."

Or, again,

(3) "Any shift in the industry supply curve occasioned by the change in costs produces no change in value added if the industry demand curve is of unitary elasticity."

Other great truths are also confirmed. I, for one, had these truths confirmed "by the Spirit," as it were, the first time I encountered them in Samuelson's Principles. I did not need to leave my family and travel 1,500 miles north in late December for a confirmation.

I am encouraged that EDA is attempting to assess the costs and benefits of alternative subsidy schemes for regional development. I am also encouraged that those making these evaluations appreciate basic economic relationships. That they also have the skills to formulate these relationships mathematically provides added comfort. Seriously, these skills will be needed before the job is done. But we still seem to be at the starting gate in terms of knowing which parameters must be measured or estimated, what proxies can be developed for those essential variables which are unmeasurable, and how one goes about empirically quantifying those proxies so that alternative subsidy programs can be evaluated.

Dr. Melichar in his paper presents a refinement of some of his earlier efforts and builds on earlier work by Tostlebe, Johnson, Brake, and others. The model concentrates on *net* cash flows rather than gross flows. *Sources* of net cash flow include net cash farm income, capital consumption allowance (depreciation) and increases in debt. Net cash flow *uses* include proprietor withdrawals and net capital flows. A projection of net capital flows is aggregated from projected flows for (1) land transfers; (2) buildings and land improvements; (3) machinery purchases; (4) changes in livestock and crop inventories and in financial assets. He then projects savings or internal sources, and concludes that the difference must be met with increases in debt.

There is much of Emil's [Melichar] paper with which I agree. It provides new and interesting insights into the relative components of capital flow. In the interest of time, I will ignore those points on which I agree and focus on points where I might disagree or feel a modification or expansion would increase the usefulness of his model.

Let me first make a few rather minor comments on Emil's estimating procedures. First, he defines the annual financing requirement associated with farm transfers as the amount of funds withdrawn from the farming sector by sellers who leave the farming sector or who are nonfarm heirs. This definition seems incomplete. The net capital flow requirements for agriculture associated with land transactions are land purchases by active farmers from nonfarmers (including farmers and heirs who withdraw these funds from agriculture) *minus* land purchases by nonfarmers (for whatever purposes) from active farmers. Since cash flow for land transfers accounts for some two-fifths of total capital flow, refinements in these estimates are important. If Emil has ignored the new equity capital coming into agriculture by nonfarm purchases of land from active farmers (as it seems to me he has done), he has overestimated the net capital inflow requirements.

His analysis of land prices ignores the impact of government payments and technology. The inclusion of these variables should make his projections more relevant.

Decisions on farm machinery purchases are associated with many complex variables. Emil has captured several of these in his formulation. But there are several factors that are not amenable to formulation *ex ante*—the most important of which is technology. Others are weather and, to a less extent, farm prices. Emil gets at weather and prices *ex post*, since these become a part of his "real machinery purchasing power of last year's cash flow." I have no good recommendation for technology, except to stress that it may be a dominant variable and excluding it ought to merit at least a footnote.

Emil correctly assumes that machinery purchases are influenced, in part, by changes in farm income the previous year. However, he then seems to assume that capital flows are independent of farm income, so that retained cash flows and increased debt become additive component sources. As a former pseudo-practitioner, I gained the impression that a significant increase in farm cash receipts often led directly to increases in both capital purchases *and* debt. That is, that the relationship between internal capital sources and external sources might be more complementary than competitive. Both complementary and competitive relationships likely exist and lie confounded in Emil's analysis of available data. I am suggesting that additional analyses using different lags and linkages might also be revealing.

I do not see as many differences between lending institutions as Emil infers in his brief comments on the supply of credit. He points out that the Cooperative Farm Credit System, the FHA, and farm supply companies raise their loanable funds in the money market, whereas commercial banks and insurance companies are influenced by other important factors affecting their supply of funds and investment alternatives. But are not those forces which affect the supply of, and nonfarm demand for, bank funds the *dominant* forces affecting the money market? Thus, I have detected very little differences between banks versus PCA's in the cyclical availability of funds. However, there are important differences in the average size of individual farm loans and in average loan maturities between these two important groups. And *these* differences might be crucial to the future long-run relative position in farm lending of these two institutions.

This leads to my main criticism of Emil's model: It is based on residual net flows rather than on gross flows. Consequently, it is concerned primarily with capital flows that must be financed. It ignores a large number of cash flow items each of which place as heavy a pressure (dollar for dollar) on a firm's liquidity as does capital flows. The case with cattle is a case in point. Total numbers of cattle in the inventory has increased only modestly, as Emil points out in Figure 6. But productivity has increased more sharply. A large part of this increased productivity results from the development of the commercial cattle feeding industry which relies on year-round feeding, with some cutbacks in late fall and winter. The dollars loaned to this industry have increased greatly, and this increase is not adequately reflected in debt outstanding January 1.

The difference in the two approaches can be seen at once by looking at the items comprising a sources and uses of funds statement. Instead of net cash farm income, capital consumption allowance and increased debt, we must now include as sources all those items listed on the left-hand side of Table 1. On the uses side, we can no longer be content with looking only at net capital flows and proprietor withdrawals, we must include all those items listed on the right-hand side of Table 1. Granted, one can make the inferences Emil makes without this detail; and granted, further, that he makes some relevant and useful inferences. But one overlooks a most critical issue affecting the financial structure of agriculture in so doing—namely, its deteriorating liquidity.

Let me fill in some figures based on our best estimates of these variables for Texas agriculture (see Table 1). Notice that annual nonreal estate borrowings constitute the largest single source of cash flow for Texas farmers. And if the trends of the 1962–70 period are projected to 1980, annual repayments on nonreal estate

Table 1. Sources and uses of funds, Texas agriculture, 1970

Cash receipts from farm marketings	3.7	Farm operating expenses	2.5
Government payments	.5	Capital expenditures	.4
Nonfarm income	1.2	Repayment of real estate debt	.4
All real estate debt extended during year	.4	Repayment of nonreal estate debt	5.0
All nonreal estate debt extended during year	5.1	Real estate purchase by active farmers	.5
Real estate sales by active farmers	.3	Ending financial assets	1.2
Beginning financial assets	1.4	Proprietor withdrawals	2.6
Total Sources	$12.6		$12.6

Source: Robison, L. J., P. J. Barry, and J. A. Hopkin, "Cash Flows and Financing in Texas Agriculture," paper to appear in *Southern Agr., Econ. J.*, July 1973.

debt will substantially surpass the total of cash farm sales, government payments and nonfarm income. Clearly, an important, possibly the dominant, source of annual loan payments is annual nonreal estate borrowings. How much inadequate loan maturities contribute to this condition should be a matter of concern. For example, if the purchase of a depreciable asset that will generate sufficient cash flow over a five-year period to justify the investment is financed over one to three years, the farmer might make a highly profitable investment that almost "does him in" in terms of cash flow. Bankruptcy courts are replete with such cases. A number of similar situations might be sighted.

If our estimates of gross cash flows for Texas agriculture are anywhere near the mark, a deteriorating liquidity is becoming serious for some farms. Loan maturity is becoming a vital criterion in agricultural finance. Therefore, I would like to see Emil's model modified to include gross flows in order to reveal what might be happening to liquidity.

Discussion: W. C. MOTES, *Economic Research Service, USDA**

The Myers, Rogstad, and Wehner paper presents an analytic framework for evaluation of alternative subsidies for encouraging regional development, according to their introductory statement. The economic characteristics of so-called "target regions" are manipulated to estimate impacts of several kinds of subsidies. The model is to identify the most satisfactory type of subsidy.

Hypothetical "target" regions are described in terms of representative firms. Representative firms have production characteristics that are national averages for their industries, and they face factor and product prices that are fixed. Thus, marginal costs and marginal prices are fixed, as are marginal elasticities of substitution among factors (and products) and between capital and labor. Some variables such as labor supply are region-specific. Most production and market characteristics are industrpy-secific, that is, national averages for the industry. A general (linear homogeneous) production function is used. Specific market interventions are postulated in terms of changes in cost or prices to recipient firms. These result in changes in resource use and factor proportions (and thus in changes in returns to resources of the region).

This model is to be part of a larger effort that will produce a refined model that will reflect the actual characteristics of a real region (rather than "representative" firms and hypothetical regions) and will allow the evaluation of specific market intervention activities on specific firms, considering the location and resources of the region.

I understand that the more powerful model is some time away but that some of the conceptual work is underway.

I am impressed by the effort. It is an attempt to use econometric models to complement the judgement of public decision makers at the national and local levels. If successful, it would help both the public and private decision makers make better choices, given their objectives.

The stakes are high. New legislative authority under the Rural Development Act of 1972 covers a range of activities from business loans to community facility grants. Concern at local and national levels about development and the process that should be undertaken to further development in ways consistent with high standards of efficiency, equity, and aesthetic quality is intense, and the debate is going on at all levels of government and in the courts. In short, communities from coast to coast and governments everywhere are contemplating direct and indirect intervention in the development process. These decision makers are desperate for information. There are almost no specific answers to a range of very important policy and administrative questions. EDA, through this effort and others, appears to be attempting to find some hard answers.

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* The views are those of the author and should not be construed as representing Departmental policy.

I like the perspective of the larger project. The model is properly seen as an evidence gathering tool that can help. It can provide a rough and vague framework to which much other information can be added to help people decide among development targets and techniques. The project is tightly linked to policy decisions. Economic theory and economic evidence are seen in perspective, I believe, and the models are designed for performance relative to important questions, even at the cost of econometric elegance.

Unfortunately, however, I was not able to come to these conclusions from the paper, or at least from the draft I had before today. The project described there is cryptic and the model vague. It is a logical model that asserts that it is not only possible, but interesting and worthwhile to describe firms and regions in abstract terms. No estimates of characteristics or parameters are given here, and it is difficult to develop much confidence in the model because so little of how it will work is shown. I have the impression from the paper and from discussions with people at EDA that this is a very partial picture of what is intended and of what is being developed and tested. Considerably more detail would have helped.

Some qualities of the effort can be seen. The model now is inflexible and not very complete. Use of general production functions, fixed prices, and hypothetical regions prevents the model from being specific with regard to the specific problems and questions of individual regions. The generalized functions make it rigid and limit its use to carefully specified conditions.

I do not mean this as a criticism. This tells me that the project is a high risk effort. It will be of significant value only if it is completed, if it works, and if it is useful to help policy decisions. And these requirements, I can tell you, imply very great risks for a research effort. It is only necessary to ask how many research efforts are submitted to tests against those three criteria to conclude that the risk is great indeed, for I see very few efforts so tested.

Thus, the first critical question is, will it work? I can't tell from the paper and I believe it is too early to know. It is really too early to see very much of the specifics of the project. The model now cannot say much about the real world. It has not yet been tested to see if it performs as expected.

On this score, I am disappointed to see that no empirical tests are scheduled, or at least EDA reports none in their 1972 research program. The project ends with an interpretation and presentation. I would be much happier to see even a general commitment to some kind of small test, perhaps using secondary data with common sense as the principal test criterion, with this test leading to a more demanding test under field conditions.

In addition to the testing, I would like to know much more about how the model will be refined. This is beyond the scope of the paper, it appears, and I am disappointed that it is. My major interest is how well the model will work and how it will be used, and it is too early to tell. The project has at least another six months before it is scheduled to end in June of 1973, and I assume the final six months will be devoted mostly to making the model more specific and removing some of the limiting assumptions. I will watch that process with great interest.

In summary, I think the project is asking the right questions, and I am happy to see this progress. I would be happier if this kind of effort were taken seriously enough to warrant a little more attention in terms of a scheduled test, given satisfactory preliminary progress.

I want to make one additional comment, and I intend it to be a critical one. I submit that the EDA-Systan project we are discussing here is a modest one. It involves complex and dynamic relationships, but we have and use serviceable estimates of most of the relationships involved. It should be a manageable task to make estimates of all of them. The concept of the model is straightforward, even though complicated, and it should be easily possible to design it, adjust it, and use it. The technology to do so is available and has been for many years.

And, the answers being sought are basic to the wise management of one program that invests a quarter-billion dollars each year—and to several other state and federal investment programs as well concerning a total annual investment of several (many) billions of dollars.

These programs have been in operation for varying periods and at varying levels of funding. But at the very least, these questions have been of fundamental importance for multimillion dollar annual programs for 10 years or more—and for multibillion dollar programs for the last several years.

This project is not the first attempt to develop applied research techniques to answer this question, nor is it the largest, I suspect. But is it not significant that after spending so much money each year for many years, we are still so far from applied research conclusions to guide it? Why has it been so difficult to design and develop good and useful research on these topics of such major concern? I mean this as a criticism, not of the authors nor of the project, but of ourselves and our profession.

It is true that the subject is complex and dynamic—that tomorrow's technological changes may make today's conclusions obsolete. The relationships are hard to measure and data are expensive and closely held. For another thing, such conclusions often involve conflicts among vested interests and among beliefs or preferences. The questions are difficult for all these and many other reasons.

But I wonder if this is the whole answer. I wonder if part of the problem is not inherent in the way we do research—the one researcher, one project approach to problems. I wonder if our preference for the abstract, rigorous conceptual world and the prestige that we award to those efforts has led us simply to neglect to apply what we know in effective attempts to solve important problems at hand.

I submit that this has happened, and that this set of problems is a case in point. I see this project as a step in the right direction and I hope it is the first of many. I would hope it sparks professional debate and interest and leads to challenges and tests and perhaps—just perhaps—some useful answers to hard questions.

Discussion: C. B. Baker, *University of Illinois-Urbana*

Capital used on farms before diminishing returns is growing relative to capital a farmer can be expected to finance in a lifetime that includes a level of living comparable with others in an increasingly affluent society. The illiquidity the farmer can be expected to bear in modern society is limited. In the past, most capital formation on farms has been financed from within the agricultural sector. Increasingly, farmers resort to external finance. Inflation has reduced the real cost of debt instruments that are written with a fixed rate of interest.

But the declining liquidity of farms increases the value of reserved credit, thus increasing the influence of lender policy on farmers' choices in production and marketing. Even more, it promotes the search for and innovations of novel financing techniques: real estate investment trusts, limited partnerships, and corporate forms, etc., raising questions on the continued dominance of debt instruments as the means of acquiring external finance. This is the view at the end of the tour as guided by Melichar. But arrival is only half the fun. Others have provided similar scenarios. We are indebted to Melichar for the analytical mapping he provides. This is especially useful if we opt for a different route and a different scenario that might be achieved by policy choices.

The key concepts are "capital flows" and "cash flows." We turn first to *capital flows*: outlays for capital formation. Forty percent of the capital flows are accounted for in land, another forty percent in machinery. The balance is accounted for in livestock and crop inventories and in financial assets: currency, demand and time deposits, and U. S. Savings Bonds. Both livestock and crops fluctuate erratically with respect to trend values, especially livestock, which also exhibits cyclical behavior. But the main show is provided in land and machinery. The land problem rests principally in how to arrive at a proper price. Only a small quantity of land is subject to transaction in a given year. In the case of machinery, much of the outlay is in replacement, reflected, therefore, largely in depreciation. The "real" stock of machinery is revealed to increase by less than one percent per year.

Having tried less successfully than he to manage the machinery component of capital flow, I can only admire Melichar's results. To have explained 91 percent of the variance in machinery stock since 1954 is no mean achievement, especially when explanatory variables make such sense as they do: harvested crop acres; the ratio of machine prices to farm wage rates; and the machinery purchasing power of farm cash flows. We must take him seriously in this major component of capital flow of the agricultural sector.

His land results are different. He reviews Reinsel's explanation of land price variation with population and money supply, noting the effects of multicollinearity on the R^2 of 0.99. In turn, he explains land price variation ($R^2=0.98$) with the general price level and the number of farms. He also uses an index of crop production, despite finding that it had little influence on land price variation. But how does this formulation improve upon the management of multicollinearity? Nor are we provided with any tests for auto-correlation. One suspects a high level of auto-correlation that would leave us skeptical with respect to projections with his land price equation. Might there be important omissions among explanatory variables?

Perhaps it would be useful to turn to more basic considerations in searching for explanatory variables in land price. Why not consider the capitalization of land income streams? One would be led at once to prices received and perhaps prices paid by farmers, to reflect changes in the cash flow to be discounted, and to a rate, *d*, at which to discount the cash flow. Would a search of theory and data reveal a more useful set of explanatory variables? Maybe it would be worth a try. Land price *is* the important part of the land component. The land component *is* 40 percent of capital flow. We *do* need to do better.

Melichar reveals that since 1965 capital flows have averaged more than half the amount of *cash flows:* gross farm income minus farm operating expenses. He defines the ratio of capital flow to cash flow as the "relative capital financing burden." It is the fraction of cash flow that would be required to finance the capital flow internally. It averaged 42 percent from 1950–54 and 50 percent from 1965–69. It reached a high of 59 percent in 1971 after dropping to 43 percent in 1970. It appears to have an accelerating positive trend.

The annual amount financed externally is given by the annual change in debt. Change in capital flow minus change in debt is the amount actually financed internally. He derives a "savings rate" as the ratio, amount of internal financing to cash flow, and finds that it has fallen from 37 percent in the early 1950's to an average of 31.4 percent for the past ten years.

Thus the percent of capital flow financed internally fell from 88 percent in the early 1950's to 65 percent in the late 1960's, owing to an increase in capital flow relative to cash flow and a decrease in the rate of "savings." Similarities in debt projections can be masked by gross differences in their expected values of capital flow, cash flow, and savings. His own expectations lead him to project 61 percent of the capital flow to be financed internally by the end of the 1970's, the remaining 39 percent externally. This will double the sector's debt by January, 1980, a projection well within the range of several others. However, Melichar's projection is reached with a declining rate of increase in the debt during the latter part of the 1970's.

Melichar calls for an analysis of his savings rate (change in capital flow less change in debt) /(gross farm income less farm operating expense). I would second this suggestion but add that we need to relate it to a savings rate that incorporates a consumption function: (change in household expenses)/(change in net cash flow). In point of fact, Melichar's savings rate turns out to be a rather erratic statistic. Consider the last five years:

1967	35.6%
1968	36.0
1969	28.5
1970	27.6
1971	36.7

Such variations leave us a little skeptical about projections based on a firm assumption of 31.4 percent from now until 1980.

A little arithmetic reveals the difference made by the assumption on Melichar's savings rate. Using the 1971 rate, 36.7 percent (of a cash flow of $28.8 billion), $10.6 billion of the annual capital flow of $14.7 billion would be financed internally. Thus, over 1972–80, sector debt would increase by $32.8 billion to a total of $97 billion. The lowest "savings" rate in the past 10 years was 27.2 percent, in 1964. If we use this rate, only $7.8 billion would be financed internally each year. Hence the debt would increase to $120 billion. There is little to rely upon to narrow this wide range of expectations. We do indeed need to investigate the determinants of "savings." But I am less hopeful than Melichar about his point of departure. We need to return to fundamentals.

In addition to consumption behavior we might investigate the terms of debt generated by external financing of the capital flow. Real estate debt forces savings through amortization. Nonreal estate debt forces savings to the extent that repayment is required at a rate that exceeds self-liquidating uses of loan proceeds. Maybe a determined attack on both consumption behavior and debt management would yield useful results. Again, the issue is important and we need to do better.

There is, finally, a technical point in relation to his "alternative projections." It seems clear that inflation increases Melichar's "savings" and deflation decreases it. Inflation increases (and deflation decreases) capital flow relative to debt. So when he postulates as an alternative to a 2.5 percent inflation rate a zero rate of inflation, should he not also reduce the rate of savings? This may seem a small point. But remember the effect of alternative rates of saving? It also serves to remind us of the complex of interrelationships in the system represented by Melichar's simulator.

We have here an excellent analytical approach to important aspects of market-oriented agriculture. My few points of criticism should not be taken to obscure his real and substantial contributions. A few more forays over the terrain mapped by Melichar will reveal features we have theorized about too long and that we need to know if we are to make rational choices affecting the structure of agriculture, its economic performance, and the welfare it provides to those who participate in it.

Communications

ON THE CONCEPT OF SUBSECTOR STUDIES*

Organization of research effort is a perennial topic of discussion in the profession. And it should be. Recently some attention has been directed to consideration of the subsector study as a meaningful unit of organization. The following comment is in response to questions I have been asked regarding the concept of subsector studies. These tentative expressions of opinion are offered as a contribution to the ongoing discussion.

How do subsector studies differ from more traditional approaches? The uniqueness of subsector studies is not in the methodology or approach but in the scope and comprehensiveness of the research. The area of research is simply defined to include both the vertical and horizontal relationships in a significant part of the food and fiber sector. It is more of a departure in research organization than a departure from traditional approaches of agricultural economics research.

Nevertheless, I would hope that changes in emphasis and approach would be associated with the specific subsector studies. I would hope for a shift from the organizing concept of static allocative efficiency to the concepts of dynamic systems and performance. The changing relationships of technology, preferences, and institutions, which are often assumed as given in analysis of allocative efficiency, should be explicitly included in analysis of the subsectors. This requires, among other things, that the research team must be more broadly oriented than is usually the case among agricultural economists. Emphasis on physical transformations and commodities needs to be expanded to include institutional, organizational, and human behavior dimensions.

Implied in the idea of subsector analyses is the consideration of both vertical coordination and competitive relationships. Research on economic organization has emphasized the firm and the industry and has tended to neglect the critical issues involved in vertical coordination. Economic theory similarly tends to neglect vertical coordination except as the firm faces factor and product markets. It seems to assume a simple linkage. Industry studies have tended to be based upon the assumption that structure and performance are related in a way similar to that hypothesized in the competitive model. Thus, we have many market structure studies of industries which measure concentration ratios and some related variables such as profits but do not get to the important questions of performance of the complex system of which the industry is a part. The question of effectiveness of the market as a coordinating mechanism is seldom an explicit aspect of an industry study.

Ray Bressler [2, p. 5] summed up the attitude of numerous agricultural economists concerning studies of industry structure as follows: "Descriptive studies of market structure have little demonstrable relation to performance; and the numbers game that so often accompanies such structural studies, and seems to provide the major basis for public policy, appears to be misguided—perhaps 'stupid' would be a more appropriate word. Especially in terms of local markets with which most of you are concerned, the important problem is not how to maintain or increase the numbers of competitors but how to adjust to the compelling pressure of technological advance for large-scale operation and at the same time insure that benefits are not converted into monopolistic gains but accrue to producers and consumers."

Emphasis on vertical coordination does not mean that the competitive characteristics of a particular industry or market are unimportant. Every market is important in coordinating the system, and the effectiveness of a market in coordinating activity will be related to competitive characteristics.

I believe our traditional subdisciplinary orientations and definitions may impede our research effectiveness. I am particularly concerned with the peculiar definition of agricultural marketing as being all that takes place from the farm gate to the consumer, and production as what takes place on farms. It seems to me marketing must refer to the exchange process at whatever stage in the sequence of production it takes place and production must refer to the physical transformation which also occurs at every stage. I would prefer to think of two parallel systems—the physical transformation system and the coordination system which controls the physical transformation system. Coordination takes place through administrative or exchange processes. Administrative coordination takes place within the firm or by governmental authority. Exchange coordination usually involves markets but not necessarily competitive ones. Major issues in subsector studies involve the extent of these two forms of coordination and the practices and institutions which affect them.

With the food sector viewed as a complex industrial system, the distinction between factor and product markets becomes less relevant. Every product is an input to another product. The sequencing of physical transformations becomes the focal point.

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* I would like to thank V. Sorenson and W. Vincent for reaction to the initial draft of these comments. A version of this paper was presented at the Technical Seminar on Subsector Modeling of Food and Agricultural Industries, Department of Agricultural Economics, University of Florida.

Even the distinction between production and consumption is misleading. For example, your household uses laundry materials to produce a clean shirt, and you use the clean shirt to produce a good impression at the office. These processes are production in the same sense that transformations which take place on the farm are production.

Closely tied to my perception of subsector studies is what I would call a systems orientation. By this I mean analysis of an economic activity in the context of a broader system. Such analysis would take into account feedback, sequences, and externalities. It includes the idea of simulation in the sense of projecting the flow of consequences from the dynamics of ongoing processes or from potential modification in the subsector. Orientation is toward understanding the interdependencies and the effects which are not immediate or obvious. This is, of course, what economists have always been about. It is implied, for example, by Marshall [3, p. 43] when he says, "The economist needs the three great intellectual faculties, perception, imagination and reason: and most of all he needs imagination, to put him on the track of those causes of visible events which are remote or lie below the surface, and of those effects of visible causes which are remote or lie below the surface." However, in practice we have tended to abstract from many of the dynamic and interdependent relationships of the real systems we have studied. It *is* necessary to simplify the real system in order to understand it; the question is where you do draw the line.

At the same time I do not perceive subsector studies limited to particular methodologies. For example, formal mathematical modeling or simulation of the total system is not an essential identifying characteristic. Formal models need to be viewed as tools. It is extremely unlikely that a subsector could be formally modeled as a complete system. We know very little about vertical coordination processes in complex systems and need considerable work on both methodology and analysis of empirical relationships before simulating total subsectors with formal models with the expectation of reliable and comprehensive prediction. Problems involving simplifying and unrealistic assumptions in mathematical modeling are well recognized. At the same time the systems models are valuable tools of analysis, and behavioral systems models are especially valuable as a framework for organizing research on a subsector. The model, of course, is no substitute for the imagination Marshall requires of an economist.

We need to avoid viewing our human social systems mechanistically, which may be implied in formal computerized models. In my opinion, the mechanistic view derived from 18th and 19th century physics has had a negative effect on modern social sciences. This vision based upon Newtonian mechanics was of perfect and comprehensive prediction. Pierre Simon deLaplace [4, p. 27] proclaimed that a superhuman intelligence "which could know at a given moment all the forces by which nature is animated and the respective positions of the entities which compose it, would embrace in the same formula the movements of the largest bodies in the universe and those of the lightest atom, nothing would be uncertain for it, and the future, like the past, would be present in its eyes." Thus the future was determined and science needed only to uncover the facts of the system to predict it. Modern physics has, of course, abandoned the idea of perfect and comprehensive prediction. The uncertainty principle, formally expressed by Heisenberg in 1927 [4, p. 141], stated that "the kind of information which was assumed by classical physics as the prerequisite to exact prediction—i.e., the simultaneous knowledge of position and velocity—was impossible of attainment in microphysics. The relationship of the two variables is such that the more accurate we measure the one the less accurate we are able to measure the other. . . . In short, we can never be certain of the future because we are never in fact quite sure of the present."

These comments on modeling are meant as words of caution and not discouragement. Systems can be studied at many different levels of aggregation and provide useful results. Systems models depend upon the grubby empirical work of finding out how particular parts of the system work, within the limits of our comprehension. I am concerned when it is implied that the model can substitute for empirical understanding.

Is subsector analysis a normative and/or positive tool of analysis? To the extent that economic analysis can be positive science, then subsector analysis could be positive analysis. Certainly an effort would be made to describe the relationships which exist in the subsector as objectively as possible. However, I view economics as primarily a normative science. I would expect that subsector studies would be undertaken with the objective of improving the performance of the subsector, if through no other means than providing participants with an improved understanding of the system in which they operate.

An interesting aside is the question of the possibility of a positive science, if by that is meant one that is value free or one which discovers objective knowledge without changing the world it studies. Boulding [1, p. 3] comments that "in the social sciences of course the generalized Heisenberg principle predominates because knowledge of the social sciences is an essential part of the social system itself, hence objectivity in the sense of investigating a world which is unchanged by investigation of it is an absurdity."

Research, to be of most use, should be prescriptive in the sense of identifying changes in practices or reforms in institutional arrangements which would improve performance and identifying for the decision–making group the problems associated with accomplishing the reform.

Here the role of the applied social scientist needs to be understood. The social scientist is not neutral, and the publicly–supported applied economist has an obligation to contribute to an understanding of the economic system and to contribute to a better use of this understanding in devising policy.

The social scientist does not solve problems but contributes to their solution through providing information and rational *evaluations*—assessments of probable consequences of alternative courses of action—within the context of legitimate political processes. To participate in this process is not the same as substituting the judgment of social scientists for those in authority and responsible for allocative and regulatory decisions. However, the fact that the researcher is not in authority does not release him from the responsibility to provide conclusions and recommendations within his competence. Both the selection of alternatives for analysis and the recommendations involve value judgments.

What are the results used for and who would use them? Findings of subsector studies ought to be presented so that they are useful in making both public and private decisions involving the subsector. Comprehensive information on a subsector, identifying trends, forces for change, unexploited economic opportunities, anticipated problems, and performance evaluation, etc., would be of value to all subsector participants in positions requiring decisions about investments, exchange arrangements, and regulations, etc.

Let me ask one last, important question. What are the implications of subsector studies for the organization of research effort? More than anything else I see the subsector as a framework around which to organize effective research concerned with the modern complex industrialized food and fiber sector. I believe the performance of the food and fiber sector is important to our well-being and that publicly supported agricultural economists have an obligation to contribute to the improved performance of the sector.

Meaningful subsector studies will require coordinated research efforts. In agricultural economics our methodological work has been cumulative, but our empirical work has tended to be fragmented in such a way that large numbers of studies dealing with a particular food subsector cannot be integrated to provide systematic understanding of that subsector. The issue is not simply one of addition of research effort, but more importantly, the relevance of the research. Many important issues in the modern food system require concentrations of effort much greater than the typical half man-year per year research projects if the results are to be timely and useful. Small uncoordinated projects simply do not provide information which is as relevant to the important problems as could be true with coordinated efforts. It is a matter of opportunity costs.

Subsector research will require coordinated programs of research. I believe the idea of a task force is appropriate. The task force puts people of different skills together on a temporary basis to achieve specific goals. We need to learn how to institute these task forces by concentrating funds and providing incentives for coordinated efforts. In the North Central Region we have been discussing remodeling our regional research. One proposal is that additional monies be allocated to organize consortiums of state and USDA economists. The consortium would have a full-time executive director who would have authority and budget to coordinate the program of research.

I am not implying that all research on a subsector needs to be under a single director or committee. However, if a critical mass could be initially concentrated on a subsector study providing an essential core of research plus a careful definition of needed research, then I believe contributing projects by independent researchers could be attracted and integrated into the research. In this case even elementary systems modeling would be useful as a technique for organizing the research and indicating areas of needed research.

Problems in coordinating research are substantial, and I do not want to minimize them. Among the many problems is the idea that creative research must be performed by a scientist working independently. I believe this is a myth. The questions and issues involved in structuring research organization and coordination deserve much more attention than we have given them.[1]

We need to study our research organization as a system just as I have argued for such studies of subsectors. The essential question is one of vertical coordination—how do we relate the output of one research activity to another to improve the performance of the research enterprise? We do not have the equivalent of a price system coordinating much of the research although there is a system of incentives relative to research activities. Clearly much of the research must be organized administratively. We need to study alternative organizational structures and incentives and use the insights available from other fields such as the theory of information systems.

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[1] Any system of organization needs to recognize that some researchers work best and others work not as well at all as independent scholars.

References

[1] BOULDING, KENNETH E., "Economics as a Moral Science," *Am. Econ. Rev.* 59:1–12, March 1969.

[2] BRESSLER, RAY G., "Market Structure and Performance—The Conceptual Framework," in *Proceedings of Market Structure Workshop*, ed. W. S. Farris, Lafayette, Indiana, Purdue University, 1966.

[3] MARSHALL, ALFRED, *Principles of Economics*, 8th ed., New York, The Macmillan Company, 1949.

[4] MATSON, FLOYD W., *The Broken Image*, New York, Braziller, 1964.

ON THE ATTITUDE OF A PROFESSION*

I'm tired of philosophers,
Of critics without cause.
I dread the daily eulogy
With B.A.E. applause.

Introspective analysers,
Prophets of our doom.
Your verbose words of black and gray
Would fill a concert room.

In each succeeding year you seem
To find another way,
To tell us that our relevance
Has somehow gone astray.

I'm tired of reading without end,
"Our data base is bad."
or, "We failed another time, my boy,
Our plight is really sad."

I'm tired, you see, of issues
I must research today,
While you but glorify the past
And cut not any hay.

You formulate the concepts.
And policy is fine.
But when it comes to grunt work,
You wouldn't waste your time.

I think it time we heard the call
Of Pollyanna dear.
The sweet and clarion voice that says,
"Our way is straight and clear."

O, Polly tell us, is it true
There just might be a way
To make a good decision
On what we have today?

Can we not move ahead
And solve the problems at our hand,
And reach ahead and look for more
Without the mourners' band?

The past was great, but better still,
Are the workers of today.
The people who will grunt
And groan, but mow that swath of hay.

Philosophers are great, my friends,
But I would rather heed,
The man who works to meet the end,
Who fills the pressing need.

ROBERT D. REINSEL
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* This poem was written as my reaction to the seminar papers of the 1972 AAEA Meeting in Florida and to the speakers at the ERS Conference in November 1972.

AAEA EDUCATION WORKSHOP: COMMENT*

The emphasis of the AAEA education workshop held in Gainesville, Florida during August 23–25, 1972, was on " . . . Defining Goals, Developing Curricula, and Improving Instruction," as indicated by the preceding excerpt from the workshop's title. The opening sessions provided a foundation for the discussion of innovative curricula development. Attention was focused on the bleak professional opportunities in traditional teaching and research roles and on thought-provoking alternatives for pioneering roles. However, it was disappointing to observe that many academicians viewed much of the sluggish demand for teachers and researchers as a "buyer's" problem. Also, attempts to identify and evaluate the merits of potentially innovative curricula or degree programs were presented in open session but for the most part were missing in group discussion. The extent to which the expertise of an invited provocateur and educator was negated—largely by disclaimers as to the worth of instruction within the departments of other disciplines and by claims of equal achievement from the purchase of a few dollars of instructional aids—was dismaying.

Four factors which could open the profession to greater achievement were recognized during the meeting: (1) the profession is now one of applied economics, which increases our opportunities to cover problem areas other than agriculture; (2) improvement in communicating knowledge possessed by members to other members, to students, and to the public is one of the greatest opportunities facing the profession; (3) there are benefits to be encountered in developing alternative means of measuring the achievement level of degree recipients, in lieu of time in residence and total credit hours; and (4) opportunities for newly entering members of the profession who show great flexibility are unlimited, given both the varied and the changing nature of the work performed by professional members. No claim is made that these points were generally agreed upon; in fact, it was the limited recognition of these as areas of opportunity rather than as problems that was so disturbing. To illustrate our reaction to one such limited response, we pose a question to the economists who judged it to be the "buyer's" problem that current graduates are being considered unsuitable for vital roles in our increasingly important junior colleges. We wonder whether they would make the same diagnosis to producers turning out unusable units of an already surplus commodity?

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* **Editor's Note:** The major papers from the 1972 AAEA Education Workshop will be published as a special supplement to the November 1973 issue of this ***Journal***.

Business and government participants in the workshop had the difficult task of exploring educational goals and curricular development which could potentially lead to a significant improvement in some of the ills of the profession. They believed that economists in business and government must be capable of analyzing varied aspects of a spectrum of problems much broader than agriculture and must be able and willing to quickly analyze urgent issues. Statement of these views led to suggestions that strong training in economic theory and quantitative methods is necessary. The need to appreciate and understand other social sciences and the humanities and to develop communication skills was discussed, but proposals for achieving these traits were narrow in scope. Causes for this parochialism would appear to be a recognition that these subjects cannot be effectively taught within agricultural economics departments, and a lack of appreciation of coursework in other departments. Yet knowledge in the humanities can greatly complement the theoretical and quantitative training of business and government economists. Increasingly, the urgent aspects of problems which business and government economists must analyze involve social issues. Identification and measurement of nonmonetary variables is a necessity, but the training of the typical economist has not adequately prepared him for such tasks.

Doctoral programs cannot reasonably be expected to provide candidates with adequate exposure to the humanities, mathematics, economic theory, and research applications. An alternative is to recruit doctoral students who have previously attained the necessary level of sophistication either in the humanities or in quantitative training. The complementary effect of the previous training of these students and the increase in amount of time they could devote to the principles and applications of economics could lead to the emergence of surprisingly superior economists from present departments, reflecting hybrid-vigor.

Active recruitment of students from other disciplines could be a means of widening the perspective of the profession. The profession could benefit from a representation of the views and problems of all segments of society affected by programs, policies, and adjustments related to agriculture. The inclusion of women and non-Caucasian males at gatherings of professionals, including education workshops, would seem to be essential to developing such representation. The effect of their absence can often be detected in the agenda topics, in the discussions, and in the conclusions of the meetings and workshops. The fact that most profession members have agricultural backgrounds and training is a compounding factor. An appropriate question for an education workshop may be, "Why is the population base from which this profession draws most of its membership so small?"

The need for alternatives to the dissertation as a measure of professional competence was pointed out by both business and government representatives. Common concerns causing them to propose a discussion of alternatives are that the dissertation experience tends to be a one time occurrence and that research presented within the thesis format is often not read even by economists, the intended audience. Professional economists are not the principal audience addressed by business and government economists. Even if they find time to rewrite their thesis research into a form comprehensible to the public and to the policymakers, or even to the professional journals, it is likely to be out of date by then. This revered institution need not be a "sacred cow" and termed a closed subject. There are possibilities for change. Some universities permit published articles to be substituted for the thesis; this could create increased flexibility for agricultural economics departments.

This alternative to the thesis is consistent with two of the four previously mentioned areas of opportunity on which workshop participants generally seem to have agreed—that the awarding of a degree should reflect a level of attainment rather than serve as an initiation over a specified obstacle course, and that economists, in general, can improve their effectiveness by developing communication skills.

In addition to training the intellect, a point of distinction was made regarding the attitudinal and behavioral training required to make team research complementary to individual research. Team research can have the synergistic effect of resulting in something more valuable than the sum of the parts. Competent team members may need a different set of attitudes and behavioral patterns than those of an individual researcher. These differences may appear semantic and subtle; however, they do exist as a change in emphasis. Present thesis projects and reward systems concentrate on individual efforts; many business and government efforts would improve with the team approach. Flexible reward systems within the profession must be developed to recognize contributions of individuals even though the end product—research report, newspaper article, or position paper—is composed of an amalgamation of contributions. The principles of specialization and division of labor are applicable to the field of economics.

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EVALUATION OF THE AAEA AWARDS PROGRAM: FINAL REPORT*

Through the years the Awards Program has been marked with numerous additions and few deletions. Judging criteria for research awards have been revised to reflect more emphasis on substance relative to method, though without slighting the latter. Program changes have generally reflected a response to Association perceptions of the directional changes in interests of its members. The overwhelming commitment of members to research is reflected in a large research component in the Awards Program. This was recognized in the last formal evaluation of the program [4], where the number and kinds of awards were generally accepted. Since that evaluation, additions have been made in teaching and extension categories. These additions reflect changing values among Association members in what they feel needs emphasis in rewards systems.

Meanwhile the program has been questioned on grounds of cost [1], judging criteria [2, 5], and reliability in the judging process [3]. Indeed there is vocal support for eliminating the Awards Program entirely. Although the extent of the support is unknown, clearly it is timely that the program be evaluated.

The element of cost can hardly be ignored. As Castle has shown [1], the large costs are incurred in the time taken to manage the program and judge the entries. The hours logged are, of course, formidable. Grove [5] has suggested an added cost: the negative effects on contenders who do not win. Part of the cash costs are offset by contributions that might depend partly on continuation of the program. Professional time spent judging entries is at least partially rewarded by communicative values received by the judges (and likely a large number of persons whose names never appear in any committee membership). Evaluation of product quality, professional development, and recognition of professional achievement are defensible in any profession. The real questions may relate to the propriety of an Awards Program as a technique for performing the functions. If the program is found relevant, how well is it performing?

In various statements, little attention has been paid to returns to the Association from the program. There is little doubt that the program has produced responses affecting the quality of education and research programs in some institutions. Cues for professional change can be gleaned from activities that win awards. The current shift from methodology to substance, in relative emphasis, is a case in point. The shift from commercial agriculture to rural development and environmental resources is reflected in awards. So also is emphasis given within recent decades to foreign economic development. Recent and proposed changes focus more attention on education relative to research programs. Others could be mentioned. Hence the communicative value of the program needs to be taken into account in suggestions for change in content and management. Are the categories of awards appropriate? Is the program managed to yield substantive visibility for the Association? Is it organized to be sufficiently responsive to changing needs?

Categories of Awards

To many the number of awards seems excessive and perhaps the number of categories as well. Others may argue that differentiation of activities of agricultural economists has not been sufficient to provide for meaningful comparisons of contributions. At present, all awards are made to persons. Yet in some current categories, and in categories that might be considered, the person may be less relevant as an award recipient than is an institution. An award may be for an activity that is inherently team-focused rather than individually-focused. Curricula developments and several types of extension activities seem relevant here. Glenn Johnson's suggested award for "multidisciplinary programs" might also be a case in point [6]. For example, should an award be considered for *administrative* contributions?

Finally, and with special reference to Masters programs, is the matter of *teachers* for the 230 or so post-high school units that offer work in "agriculture" and/or "economics." Do we know the requirements for success for a teacher in this environment? Can they be met in a suitably designed Masters program? And again, could the Awards Program be used as a vehicle to reward innovations that are desirable in this area? The units here are so diverse in scope and orientation that the prerequisites may defy simple or single-valued conceptions. They vary from vocational orientations to "liberal arts"—from programs to equip students with marketable skills to programs that provide students with an appreciation and understanding of the role of agriculture in the economy of the nation and world, or the role of economics in the performance of agriculture.

We have nothing comparable to the farm-centered extension programs that would link us to farm-related firms in factor and product markets, to the decision-making bodies that manage communities and regional agencies, or to the non-Land Grant educational units. These gaps in the scope and function of our establishment deny us an "image" in the minds of prospective employers. But more importantly, they also deny us a "feedback" mechanism so necessary to the development of educational programs relevant to these markets. Can the Association Awards Program be used as one instrument to make a useful contribution?

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* Prepared by C. B. Baker, General Chairman, AAEA Awards Committees, with assistance from John Goodwin, R. W. Herdt, J. C. Purcell, James Seagraves, and Jean Wyckoff, current committee chairmen; from J. O. Gerald, John Malone, Gene McMurtry, and Eldon Weeks, past committee chairmen who participated in the evaluation process; and from B. F. Stanton, incoming General Chairman, who participated in the final stages of the review.

Awards Management

Have we made the proper decisions with respect to *cash* awards? There is considerable support for eliminating cash awards for nonstudents. But was it advisable to reduce awards for Doctoral dissertations to the level of awards for Masters theses? What about raising the latter to the previous level of the former?

Are there other means that would add visibility to recipients and to the award-winning activities? An example would be time set aside at our annual conference for a demonstration of the teaching program or the extension program that has won an award, a summary of results from the research award winners, etc. Could award winners, especially in teaching and extension categories, constitute a panel of consultants that could be drawn upon with the help of outside financial support? The key here is to find a way to improve on the professional enrichment provided by the program, in whatever form it should survive.

Program Management

Contest entries are judged almost entirely by peers. Researchers are selected for committees on theses and published research. Teachers are selected for teaching awards. Extension personnel judge extension entries. Should the entries be evaluated solely by peer evaluators? Extension and teaching personnel might add relevance to judgments of research committees. They are the primary "users" of many research results. Researchers might add rigor to comparisons among teaching and extension entries. Could nonacademics be usefully added to all? We *do* use them, sparingly, in the current Published Research Committee. A small start has been made to use extension personnel as well. Such changes might give substance to one of Johnson's suggestions [6]: "to give relatively more recognition to practical prescriptive research." They will add to the problems of reaching consensus, already substantial enough [3]!

Current selections for judging committees are made by the Association President, in consultation with the General Chairman of the Awards Committees. In turn, the latter solicits suggestions from individual committee chairmen. No fixed rules exist for tenure on committees. There is a general attempt to limit membership to three years. The chairman of a committee, however, frequently has a longer total tenure. He may have served two or three years as a member *before* he accepts the chairman obligations and then serve for a year or two as chairman. The Evaluation Committee discussed these issues without arriving at a recommendation for improvement.

Responsiveness to Change

The Awards Program *has* been responsive to change. The French Committee [4] found a high degree of consistency in awards categories and professional commitment, *for that time.* Subsequent changes have reflected the growing relative importance associated with teaching and extension activities. In the decades of the 1950's and 1960's, the program reflected the prevailing emphasis on research methods. It is responding to the current call for substance in research. Given the informal character of any feedback and the other preoccupations of program managers, the responsiveness of the program is little short of remarkable.

The Awards Program is retarded in its responses by a mechanical problem. "Announcements" published in November govern the contests for the following year. Copy for "Announcements" are due to the editor no later than August 1. The Association meets later in August, too late to provide a chance to communicate with Committee personnel or with the Executive Board of the Association. The problem is aggravated further by the fact that the Board meets before the Association meetings, thus precluding a chance for Committee members to convene before the Board does.

Recommendations

1. Awards
    - 1.1 Continuation of two awards for excellence in undergraduate teaching: one for the teacher with ten years or less experience; one for the teacher with more than ten years experience.
    - 1.2 Two awards for excellence in extension education: one for the individual with ten years or less experience; one for the individual with more than ten years experience.
    - 1.3 Awards not to exceed four and in cash value not to exceed $250 per person and $750 per level for excellence in graduate student performance at each of two levels:
        - 1.31 Masters programs, based on evidence supplied in theses or comparable documents.
        - 1.32 Doctoral programs, based on evidence supplied in doctoral dissertations.
    - 1.4 Awards not to exceed five, for publications:
        - 1.41 Not to exceed two for publications judged for their quality of discovery (theory, method, related scholarship).
        - 1.42 One or two for publications judged for their quality of communication (classroom or other).
        - 1.43 One for the publication aged more than four but less than eleven years, judged for the enduring quality of its professional contribution.

2. Awards management
    - 2.1 In the Program Brochure, provided at the Annual Awards Program, the name and entry be listed for all entries accepted for judging, except in the publications categories.

2.2 In an exhibit booth at the Annual meeting, the nominating (and other relevant) materials be displayed for all award winners.

2.3 The awards be presented in a program separate from the Fellows lecture.

2.4 Coordination be developed to lessen the time used in making undergraduate awards and to add to the dignity of the total Awards Program.

2.5 Provide in the Annual meeting of the Association for two sessions dealing with teaching and extension, organized by the chairmen of the respective Awards Committees but led by award winners.

2.6 Constitute a panel comprised of teaching and extension winners available for interstate visits with financial support for travel and communication sought from outside funding agencies—perhaps on a cost-sharing basis.

3. Program management

3.1 No major change with respect to awards indicated in 1.1 and 1.3.

3.2 With respect to awards indicated in 1.2, the current judging committee would select two winners instead of one. Administration of effective programs and publications would still carry weight in the selection of individuals to be honored. However, specific reference to "extension publications" would be discontinued in favor of publications generally considered for communicative value. (See 1.42, above; 3.3, below.)

3.3 For awards indicated in 1.41 and 1.42: a Publication Awards Committee of sixteen members be selected, eight each in subcommittees coordinated by a single chairman. In one of the subcommittees, members would be selected for their judgment in the quality of discovery. In the other, the members would be selected for their judgment in the quality of communication. The nominator of a current publication entry would be required to identify the quality on which the entry is to be judged. The entry would be judged by the subcommittee thus identified. Nine copies of each publication would be required for each nomination.

3.4 For the award indicated in 1.43, a committee of nine members (including the chairman) would be named to evaluate entries that include but are not restricted to those nominated by members of the Association on the ballot used to nominate Association Fellows. Eligible entries are restricted to (1) articles in *AJAE* (or *JFE*, as applicable), whether or not the author(s) is (are) Association member(s); and (2) publications by author(s) who, at the time of publication was (were) member(s) of the Association, regardless of the journal or other medium in which the entry was published. Nominations of entries must include a statement on the basis claimed for the enduring quality. It is recommended that membership on this committee be restricted to no more than three years.

4. Program modification

4.1 The General Chairman, in consultation with chairmen of individual committees continue to be given considerable autonomy in organizing and managing the program and the awards, subject to judgments of current Association Presidents.

4.2 In the agenda for the *Winter* meeting, the Executive Board include a commitment of time to discuss the Awards Program. The Winter meeting is scheduled so as to reduce the time lag for change from two years to one. The General Chairman could bring to the Board issues that have surfaced in his contact with chairmen of judging committees at the Summer meeting.

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References

[1] CASTLE, EMERY N., "Report of the Awards Committee," *Am. J. Agr. Econ.* 52:858–860, Dec. 1970.

[2] ———, "Has the AAEA Become 'Awards Happy'?: A Reply," *Am. J. Agr. Econ.* 54:140–141, Feb. 1972.

[3] CRAMER, GAIL L., "Ph.D. Dissertation Awards: Does the Best Always Win?—Comment," *Am. J. Agr. Econ.* 54:141, Feb. 1972.

[4] FRENCH, BEN C., "Report of the 1966 Committee Appointed to Evaluate the *AFEA* Awards Program," *J. Farm Econ.* 48:1725–1731, Dec. 1966.

[5] GROVE, ERNEST W., "Has the AAEA Become 'Awards Happy'?: A Comment," *Am. J. Agr. Econ.* 54:139–140, Feb. 1972.

[6] JOHNSON, GLENN L., "The Quest for Relevance in Agricultural Economics," *Am. J. Agr. Econ.* 53:728–739, Dec. 1971.

SACRED COWS: COMMENT

The recent attempt to define the beneficial effects of one group of Sacred Cows and the destructive effects of another [13] fails to define the basic problems giving rise to these effects; thus misleading implications may arise when we examine market effects governing the management of livestock in the economies under question. Discussion of three points may help to clear up the problem: what were the components and conclusions of the Indian controversy; of what importance is this research to the LDC's in general; and what implications are apparent for the United States livestock industry.

Regarding the first point, Perelman's comments on the sacred cow controversy in India follow a now familiar pattern as we continue to learn of the complexities of economic–cultural systems in the LDC's. First, cursory observations of apparent irrationalities in economic behavior lead to statements condemning the various causes of the misallocation, in the case under consideration, the doctrine of *ahisma*[1] and its supposed function of maintaining excess numbers of unproductive cattle. Harris [7, p. 51] states this aspect of the problem: ". . . many agree that *ahisma* is a prime example of how men will diminish their material welfare to obtain spiritual satisfaction in obedience to nonrational or frankly irrational beliefs."

Second, closer observation and study of the problem opens new possibilities for explanations of observed behavior. Analysis is then applied and we find what the anthropologists may have told us in the first place, i.e., "If you get the cognitive map of the people and see its operation in the total context of the human and environmental setting, then what at first seemed bizarre is likely to turn out to be rational" [11, p. 205].

It is the economic analysis of the problem which I feel Perelman glosses over. Contrary to his condemnation of economists for their superficial treatment of the problem, a careful reading of the literature would have revealed a number of studies on the problem [2, 3, 4, 10, 14, 15, 16] with the concensus being that rational adjustments of bovine stocks do take place and, while some improvements are certainly possible, large stock adjustments would not be feasible on either efficiency or equity grounds [9, 14].

In summary, analyses have shown that demographic characteristics of the bovine population indicated stock adjustment processes were occurring in response to regional economic conditions. The present form of adjustment is neglect and eventual starvation [3]. This is simply an alternative to the population adjustment procedure used in most areas of the world (the slaughterhouse). Merely substituting one form of adjustment procedure for the other, while no doubt causing some economic and distributional effects, would result in limited changes in animal numbers or herd compositions, and " . . . any significant reduction of the bovine population in the country might be difficult to achieve without major technological and institutional changes in agriculture" [15, p. 32].

Regarding the second point—the relevance of this research to other LDC's—the examination of the surplus cattle question has led to some in-depth work on a major, and in some cases *the* major capital asset of most peasant farmers, their bovines. Two conclusions were evident: the complexities inherent in analyzing bovine complexes in the LDC's have again been illustrated,[2] and the crucial importance of demographic characteristics of animal populations as an analytical tool was emphasized. While most bovine production–utilization systems are not as complex as India's, the fact remains that multiple roles constitute the rule rather than the exception [5, 6, 17, 18]. Given this multiplicity of functions, it is little wonder that special significance is often attached to bovines; slaughtering regulations as a means of avoiding the depletion of animal stocks to reap short term gains is not unique to India.[3]

The third point concerns the utility of the above discussion for the sacred cow of the United States and the U. S.'s highly visible feedlot economy. Here Perelman fails to treat the problem in its proper context which is simply one manifestation of the enormous dependence of U. S. agriculture on fossil fuel subsidies in its energy chain [1, 12]. Although in the distant future the United States may be forced to emulate the bovine–based mineral economy common to India and many other areas of the world, it would take an unprecedented short–term shift in the terms of trade against petroleum products to set the wheels in motion through the competitive market mechanism.

The alternative is making explicit the social costs[4] involved to encourage substitution and induced innovation effects to reduce the social costs of feedlots. This leads to the next point: any policy to rectify the sacred cow of the feedlot system will, as in the case of India, lead to substantial income redistribution. This follows from the policy choices available, e.g., feedlot charges or fines, higher feedlot input prices through the increased mineral fertilizer prices necessary to increase use of manure, or a direct payment to farmers to encourage their use of manure.

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[1] The doctrine of *ahisma* is the Hindu principle of the unity of life.

[2] A model developed by the author [5, pp. 129–130] for a simple system required three resources, two final products, two intermediate products, and two pairs of joint products. A model used by Raj [15, p. 3] for India treated cattle as producing four goods with 12 technological and price assumptions required to obtain some elementary results.

[3] Thailand imposed regulations following World War II. Raj [14, p. 717] cites an example of regulations in the 1920's in China.

[4] Willard Cochrane once mentioned that he suggested a tax on manufactured fertilizer as a step towards equalizing its private and social costs when he was director of agricultural economics. He also said that a suggestion was as far as the idea was ever likely to become.

The appropriate comparison, then, is between two bovine systems, each tending to be specialized but at opposite ends of the production spectrum—one system providing the basis of a mineral economy, the other aiding in the destruction of that economy. The fact that the United States was never in a position comparable with that of India makes comparisons of little value in seeking solutions for these problems. So we are left with two nations, both with sacred cows, both maintaining a tenuous equilibrium with their environment, and both likely to stay there without major changes in both the institutional structures and resource availabilities which presently govern their agriculture. It is to the nature and possibilities of these changes that we must turn but for radically different reasons in the two countries.

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References

[1] Black, J. N., "Energy Relations in Crop Production—A Preliminary Survey," *Proceedings of the Association of Applied Biologists* 67:272–277, March 1971.

[2] Dandekar, V. M., "Cow Dung Models," *Econ. & Political Weekly* 4:1267–1271, Aug. 2, 1969.

[3] ———, "Problem of Numbers in Cattle Development," *The Econ. Weekly* 16:351–355, Feb. 1964.

[4] ———, "Sacred Cattle and More Sacred Production Functions," *Econ. & Political Weekly* 5:527–531, March 21, 1970.

[5] De Boer, A. John, "Technical and Economic Constraints on Bovine Production in Three Villages in Thailand," unpublished Ph.D. thesis, University of Minnesota, 1972.

[6] Dyson-Hudson, Rada, and Neville Dyson-Hudson, "Subsistence Herding in Uganda," *Scientific American* 220:76–89, Feb. 1969.

[7] Harris, Marvin, "The Cultural Ecology of India's Sacred Cattle," *Current Anthropology* 7:51–59, Feb. 1966.

[8] Heston, Alan, "An Approach to the Sacred Cow of India," *Current Anthropology* 12:191–197, April 1971.

[9] Mencher, Joan, "Comment on Heston," *Current Anthropology* 12:202–204, April 1971.

[10] Mishra, S. N., "Some Inferences from Compositional Changes in India's Livestock Population (1920–1966)," *Indian J. Agr. Econ.* 24:40–50, Dec. 1970.

[11] Nash, Manning, "Comment on Heston," *Current Anthropology* 12:204–205, April 1971.

[12] Odum, Howard T., "Energetics of World Food Production," in *The World Food Problem*, A Report of the President's Science Advisory Committee, Washington, D.C. 3:55–94, Sept. 1967.

[13] Perelman, Michael, "Sacred Cows," *Am. J. Agr. Econ.* 54:526–527, Aug. 1972.

[14] Raj, K. N., "India's Sacred Cattle: Theories and Empirical Findings," *Econ. & Political Weekly* 6:717–722, March 27, 1971.

[15] ———, "Investment in Livestock in Agrarian Economies: An Analysis of Some Issues Concerning 'Sacred Cows and Surplus Cattle'," *Indian Econ. Rev.* 4:1–33, April 1969.

[16] Rao, C. H. Hanumantha, "India's 'Surplus' Cattle: Some Empirical Results," *Econ. & Political Weekly* 4:A225–A227, Dec. 1969.

[17] Ruffener, William R., "Cattle and Water Buffalo Production in Villages of Northeast Thailand," unpublished Ph.D. thesis, University of Illinois, 1971.

[18] Schneider, H. K., "Economics in East Africa Aboriginal Societies," in *Economic Transition of Africa*, ed. M. J. Herskovits and M. Harwitz, Evanston, Northwestern University Press, 1964.

SACRED COWS: RESPONSE

De Boer makes the charge that the U. S. and Indian economies have never been comparable [4]. He is only partially correct. Genovese [7, p. 143] has written:

> . . . the [Ante–Bellum] South was confronted with a paradox: an abundance of livestock and an inadequate supply of meat and work animals. Contemporary agricultural writers were not unaware of this situation, and repeatedly called attention to it.

For instance, the Reverend G. Lewis complained in 1854 that Georgia cattle were " . . . objects of pity, not to be fed upon but to be fed. Left to shift for themselves all winter, their bones look and stare at you" [6, p. 201]. During the Civil War, Confederate troops complained that the animals supplying them with beef had to be held upright for shooting [7, p. 116].

Like India, the South had strong economic motives for maintaining "Sacred Cows" in the Ante–Bellum period. The South was predominantly rural without the "more concentrated markets that might have encouraged animal husbandry on a large scale" [7, p. 116]. Moreover, "improvement of cattle breeds . . . [and] the development of adequate transportation facilities . . . [to transport the cattle to market] . . . involved heavy investment of capital, which the South [as well as India] lacked" [7, p. 112].

Useful future comparisons can be made since pundits of the Green Revolution look to the time when the LDC's will emulate the capital intensive technology of U. S. agriculture. When that age comes, the Sacred Cow will live out his last days in the feedlot.

Small–scale Indian agriculture is remarkably efficient. This view is supported in that "historical evidence suggests that [nonfarm agricultural] inputs tend to be in the magnitude of 3 percent of national income independently of time, place and level of per capita income" [5, p. 47]. Yet in India these inputs represented merely 1 percent of the 1963–64 net domestic product [5, p. 47].

To judge from this figure, Indian agriculture has apparently been badly starved of external inputs. The Indian economy would probably be more rationally organized if the amount of external inputs available to farmers increased, but mechanization would require too many of these, and the effect of the mechanization after the fashion of U. S. agriculture would be to starve other sectors of needed materials.[1] For instance, if Indian agriculture were to spend as much for fuel as U. S. agriculture does, fuel costs would total 4 to 5 percent as much as India's 1970 National Product [5, p. 64]. If Indians also spent as much as U. S. farmers do for depreciation and repairs of farm machinery, these costs together with the cost of fuel would total more than 10 percent of India's 1970 National Product.

Since India's population is 2.5 times as large as the U. S. population, fuel and machinery costs would actually be equivalent to 25 percent of the 1970 Indian National Product, assuming that the costs per capita were equivalent to comparable U. S. costs. With new technology we can expect the use of other sophisticated inputs. Fertilizer and pump sets alone are expected to consume well over 3 percent of India's domestic product [5, p. 63]. These statistics show how inappropriate American agriculture is for India today.

But the Indians are poor and Americans are rich. De Boer hits upon one key reason—the dependence of U. S. farmers on fossil fuels. Elsewhere I have calculated that U. S. farms require an average of more than five calories of fossil fuel energy for every calorie of food they produce [10]. Later calculations indicate that this ratio may have been too modest [9]. Should the price of energy rise substantially, then U. S. farmers will have to learn from the "primitive" LDC's where one input serves numerous needs. As De Boer points out, the multiplicity of functions is one of the most important characteristics of the Sacred Cow.[2]

De Boer is correct that any adjustment in the price of energy sufficient to wipe out the advantages of mechanization would be unprecedented. He also points out that any alterations in our system through marginal tinkerings with prices are bound to be inconsequential. Given the only two alternatives which De Boer recognizes, the Sacred Cow is probably a rational adaptation. Even Karl Marx [8, p. 237], no great defender of the status quo, recognizes the truth in this position when he cited with approval a parliamentary report from 1867: "While the peasant farmer starves, his cattle thrive. . . . The prescriptions of superstition, which appear cruel to the individual, are conservative for the community: and the preservation of the labouring cattle secures the power of cultivation, and the future sources of life and wealth."

Unfortunately De Boer overlooks a third alternative; what is required is major technological and institutional change in agriculture as well as in the rest of society. These changes are required in India as well as at home so long as men are deprived of an opportunity for a decent life.

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[1] Nevertheless, Raj [11] as well as Bose and Clark [1, 2] have calculated that the Indian or Pakistani peasant is rational in choosing animal traction over mechanization.

[2] The multiplicity of functions which cattle serve around the world can be extended much further. Dung is also used for plaster and dressing for wounds; ashes from bones are used for mouth wash, tooth paste, and cosmetics; urine is used for washing, making cheese, and dressing skins [3, pp. 251–252].

References

[1] BOSE, SWADESH R., AND EDWIN H. CLARK II, "Some Basic Considerations on Agricultural Mechanization," *Pakistan Development Rev.* 9:271–300, Autumn 1969.

[2] ———, "The Cost of Draft Animal Power in West Pakistan," *Pakistan Development Rev.* 10:175–192, Summer 1970.

[3] CRANSTONE, B. A. L., "Animal Husbandry: The Evidence from Ethnography," in *The Domestication of Plants and Animals*, eds. Peter J. Ucko and G. W. Dimbly, Chicago, Aldine, 1969.

[4] DE BOER, JOHN, "Sacred Cows: Comment," *Am. J. Agr. Econ.*, this issue.

[5] DOVRING, FOLKE, "Macro Constraints on Agricultural Development in India," *Indian J. of Agr. Econ.* 27:46–66, Jan./March 1972.

[6] GATES, PAUL W., *The Farmers Age: Agriculture, 1815–1860*, New York, Holt, Rinehart, & Winston, 1960.

[7] GENOVESE, EUGENE D., "Livestock Economy in the Slave Economy of the Old South—A Revised View," *Agr. History* 36:143–149, July 1962 (reprinted in his *The Political Economy of Slavery, Studies in the Economy and Society of the Slave South*, New York, Vintage, 1967).

[8] MARX, KARL, *Capital*, Vol. II, New York, International Publishers, 1972.

[9] PERELMAN, MICHAEL, "Energy Use in Agriculture," unpublished manuscript.

[10] ———, "Farming with Petroleum," *Environment* 14: 8–13, Oct. 1972.

[11] RAJ, K. N., "Investment in Livestock in Agrarian Economies: An Analysis of Some Issues Concerning 'Sacred Cows' and 'Surplus Cattle'," *Indian Econ. Rev.* 4:53–85, Oct. 1969.

USES OF THE ARITHMETIC MEAN IN FARM POLICY

"Average" has become a dirty word for agricultural economists in recent years. Somehow the "golden mean" of the ancient Romans has given way to a generalized "meanophobia." This is unfortunate because it has induced a frantic search for distributions—by size or by geographic area but preferably both—which for the most part are simply not available.

This antipathy to averages was probably started by T. W. Schultz in 1945 when he proposed separate income accounting for "production and welfare" parities, with the latter requiring a size distribution of income instead of the usual "income parity" averages on a per capita basis [9, 10]. Subsequent development of "economic size classes" of farms in the Census of Agriculture, based on the previously available size distribution of value of farm products sold, was an added stimulus. In 1960 an "interregional" research project at Iowa State [4] suggested that parity income should be determined separately for "typical farms," using the "cost and returns" data collected by ERS.[1] A "parity returns" formula was proposed, based on the ratio of farm returns to labor and management to returns to labor and management in other occupations.

The Iowa State study made some sense because the "typical farms" were essentially averages of modal farms in specified areas. The main difficulty was that "cost and returns" data were available for only some types of farms and for only a fraction of the farms that had to be covered under the income parity formula. It was the misguided and floundering attempts to overcome this difficulty which led ERS and the USDA down the path of serious aberration, resulting in the fragmentation and final destruction of the income parity concept. Latching on to the comparatively new "economic size classes" in the census, ERS treated them as homogeneous groups of farms—which they are not except in terms of value of sales [2]—and applied the "parity returns" formula developed at Iowa State to each class separately [6]! The results were given to the National Advisory Commission on Food and Fiber, which promptly endorsed them [8], and to the Congress [13], which quietly rejected and buried them.

The latter treatment was justified because the "parity returns" report to the Congress blandly asserted, with no proof whatever—not even any discussion—that a definition "in terms of averages for all farm operator families . . . is not a satisfactory approach to the problem of parity income" [13, p. 7]. This assertion, of course, flew directly in the face of the obvious fact that both price and income parities have *always* been determined in terms of averages. Having thus set themselves an unnecessarily difficult task, the authors of this report proceeded to cook up, most circumspectly to be sure, a number of annual farm income size distributions so that each size class of farms could have its own separate calculation of parity returns. This was simply sloganeering as a substitute for analysis.

If it makes sense to calculate "parity returns" for each of the census size classes, as was done in the "parity returns" report, why should it not make just as much sense to have separate calculations for, say, 100 value-of-sales groupings, or 1,000 such groupings, or 100,000? Why, in fact, did the authors not array all of the nation's farms according to the size of their gross value of sales, and then set up a required "parity returns" ratio for each farm individually? It would be perfectly logical, granted the original premises underlying the "parity returns" report. In reality that report simply showed that it is possible to carry the fear of averaging much too far. It does not seem so bad, really, if the alternative is squarely faced. Averaging is the essence of the parity concept because the homogeneous treatment of a heterogeneous people has been an important aspect of the American Dream. Why then should we change it for farmers?

The arithmetic mean is always of some interest, even if the shape of a size distribution has changed. But if that shape has *not* changed, if the *relative* distribution of farms by value of sales has not changed significantly, though rising steadily in its overall absolute level, then the arithmetic mean becomes a *good measure* of what is happening—the measure of choice.[2]

The fact that "empirical size distributions seem to have an underlying stability across time and geographic areas" [1, p. 87] was part of the "folk wisdom" of old-time "agricultural economic statisticians." Their more modern counterparts, the "new" agricultural econometricians, somehow lost this insight during the 1950's and 1960's. Citing the same old relative distribution of farms in terms of cumulative value-of-sales percentages, contrasted with cumulative number-of-farms percentages, these "new statisticians" expressed astonishment and dismay, insisting without any justification that the situation they were describing was essentially a *new* one, with a quite unprecedented increase in the relative concentration of farm products sold in the larger farms.[3]

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[1] For "commercial family-operated farms by type and location."

[2] Nevertheless, the "meanophobia" of agricultural economists dies hard if at all. In 1970 Foote [3] used "Farm Income Per Capita or Per Farm—A Meaningless Concept" as the heading for his Chapter VI

[3] This is what I was talking about in 1963 when I said that contrasts of this kind—e.g., the top 5 percent of the nation's farms account for half of the total value of sales—"constitute the most overworked cliché in contemporary agricultural economics" [5, p. 284]. There have been no significant changes in these percentages, so their constant

This has always been nonsense, of course, but it was not until 1969 that ERS finally rediscovered, *mirabile dictu*, that "the relative size distribution among farms remains surprisingly constant" [12, p. 2] as farms in general become fewer and larger. What should have been known intuitively was rediscovered only after laborious research [7], and this was supplemented by further research on the size distribution in terms of acreage, with the conclusion that "the percentage distribution of farms by size classes during 1935–64 remained relatively stable despite large increases in average size of farm" [1, p. 93].

But now comes one Con Taeuber of the Census Bureau [11], paying his routine respects to the "meanophobia" among agricultural economists,[4] and proposing $5,000 or more of sales as a new farm definition—one that would lop off a half or more of the farm income size distribution at its lower end! This would *really* change the shape of the distribution, destroying all comparability with previous years, and making the arithmetic mean truly "meaningless" for the first time.

Small farm producers have always been a nuisance to the data gathering agency,[5] but Taeuber claims that "operational difficulties in identifying the units to be included in the universe are not the primary reasons for a review of the present definitions" [11, p. 361]. But what *are* these "primary reasons?" Taeuber does not say; he simply repeats the old clichés from ten years ago. If small farms were *easy* to identify and include in the census, would Taeuber still insist that they should be placed in a sort of statistical limbo? Should it not suffice, in fact, to make such further modification in the definition of a farm as would continue to maintain a considerable degree of constancy in the *relative* size distribution of the value of farm products sold? Would not a cutoff point around $500 instead of $5,000 probably do that?

At any rate, and regardless of how a farm is to be defined, the arithmetic mean needs to be rehabilitated as a useful measure of central tendency. The current demand for size distributions and other kinds of detailed data systems has some merit, to be sure. The point simply is that, when this demand is not met, what information we have should not be declared meaningless and thrown away. So go ye, oh agricultural economists—and census demographers too—and demean no more the arithmetic mean as being meaningless. 'Taint so.

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emphasis and repetition has been antithetical to a reasoned and common sense view of what has been happening in agriculture. In the context of an unchanging *relative* distribution of farms, the dropping or disappearance of very small farms (it does not really matter which) is simply a form of concrete recognition of the growth in agriculture as a whole, consistent with growth of the national economy.

[4] See the last two sentences of Taeuber's introductory paragraph [11, p. 360].

[5] Except perhaps in 1935 when the enumerators, in a kind of make-work project, found more farms than ever before or since.

References

[1] Boxley, Robert F., "Farm Size and the Distribution of Farm Numbers," *Agr. Econ. Res.* 23:87–94, Oct. 1971.

[2] Duvick, Richard D., and Joseph N. Uhl, "Large Farms and Above Parity Returns: Inseparable or Just Good Friends?" *Am. J. Agr. Econ.* 51:179–182, Feb. 1969.

[3] Foote, Richard J., *Concepts Involved in Defining and Identifying Farms*, USDA ERS 448, June 1970.

[4] Fuller, Wayne, *et al.*, *An Alternative Parity Formula for Agriculture*, Iowa State Univ. Res. Bul. 476, Feb. 1960.

[5] Grove, Ernest W., "The New Dichotomy in Agriculture," *J. Farm Econ.* 45:277–284, May 1963.

[6] Masucci, Robert H., "Income Parity Standards for Agriculture," *Agr. Econ. Res.* 14:121–133, Oct. 1962.

[7] Mighell, Ronald L., "Concentration in Farming and Transition Bias," *Am. J. Agr. Econ.* 51:1114–1118, Dec. 1969.

[8] National Advisory Commission on Food and Fiber, *Food and Fiber for the Future*, Report of the Commission, Washington, D. C., U. S. Government Printing Office, July 1967.

[9] Schultz, Theodore W., "Income Accounting to Guide Production and Welfare Policies," *Proceedings of the Western Farm Economics Association*, 1945, pp. 58–66.

[10] ———, "Production and Welfare Objectives for American Agriculture," *J. Farm Econ.* 28:444–457, May 1946.

[11] Taeuber, Conrad, "Future Census Data for Agriculture: Comment," *Am. J. Agr. Econ.* 54:360–363, May 1972.

[12] Upchurch, M. L., "Dynamics of Commercial Agriculture," USDA, ERS, talk given at the Annual Agricultural Outlook Conference, Washington, D. C., Feb. 18, 1969.

[13] U. S. Department of Agriculture, *Parity Returns Position of Farmers*, Report to the Congress, Senate Document No. 44, 90th Cong., 1st sess., Aug. 1967.

Reviews are listed alphabetically by authors.

Book Reviews

Beckford, George L., *Persistent Poverty*, New York, Oxford University Press, 1972, xxvii + 303 pp. ($7.50 cloth, $2.95 paper)

"In our view, economists have been too much concerned with trying to explain the process of development without first trying to understand the nature of underdevelopment" (p. 196). In pursuit of this understanding George Beckford makes a contribution to the growing body of Third World literature on political economy that is important on two levels: in terms of the data and analysis presented, and in terms of the author's thought processes which it reveals.

The plantation system stands condemned, in his eyes, for the persistence of poverty in plantation economies. No amount of tinkering will set this right. ". . . The plantation system must be destroyed if the people of plantation society are to secure economic, social, political, and psychological advancement" (p. 215).

He identifies 33 separate plantation economies, which in number are concentrated in the Caribbean and Latin America but in terms of people involved have their dominant impact in Asia. In these economies the plantations have the best land, can attract labor, and have access to credit. Peasant producers have the poorer or hilly lands, cannot compete with plantations for wage labor, and have little credit. Population growth puts great pressure on peasant land resources and leads to peasant-plantation conflict. A dualism results that polarizes, hardens and perpetuates the plantation structure. "The disintegration of the system cannot result from evolutionary processes" (p. 44).

Some of the most pertinent economic analysis concerns the inadequacy of contemporary economic theory when faced with the internal pricing policies of integrated plantation firms. The absence of market-determined prices at various stages of production and processing leads to "incalculability," to use Lloyd Best's term which Beckford borrows. The result is a distorted set of price weights by which the importance of plantation activity is measured. Plantation output may be overvalued in relation to domestic food crop output while at the same time the plantation sector of the integrated firm (sugar, bananas, rubber) may be undervalued in relation to the contribution made to total company revenues by related processing, transport, storage and marketing activities.

Beckford presents data to show that in many international plantation corporations the capital invested in transport, storage and processing operations far exceeds the capital involved in land and plantation field crop enterprises. As a consequence, management is under pressure to keep its expensive ships, mills, and storage plants operating at capacity. Plantation field operations are thus dominated by decision rules that maximize output or throughput, rather than profits. And where profits are the goal, they are profits from the total plantation system and not from its land-based segments. Developing host countries are frequently the ones that suffer. A low price for sugar cane means a higher profit in cane processing. A low price for refined sugar means a higher profit in packaging and marketing. Where management rewards are based on physical output, the incentive structure in the plantation system encourages operation of the plantation proper as a producers' cooperative, with profits passed up the line to the metropolitan parent company by judicious internal pricing and local political manipulation.

It is a strong indictment, and one that would have been understood in the Dakotas at the turn of the century when similar charges of oppression by railroads, millers, and Wall Street were the stuff on which the Populist movement was nourished.

The analogy is apt, for it is Beckford's aim to present an analysis that can generate Third World economic and political nationalism on the scale needed to overthrow the system. The plantation is presented as a foreign importation, forced on the blacks and coloreds of the Third World by dominant whites of the North Atlantic. In this version the plantation system may be a useful vehicle for mobilizing unrest, but we are left with some key unanswered questions. There are poverty stricken parts of the world that have not known plantations. There are problems of one-crop economies that are independent of plantations. And there are post-reform societies that have retained or reconstituted their own versions of absentee-controlled, labor-brigade structured agricultural firms that look very much like plantations but are not included in conventional listings. Beckford is quite right to emphasize the significance of Cuba in this context. The plantation has been retained under state control, guided by an ideology that is as foreign and North Atlantic in origin as any introduced by sea-captains in the 15th and 16th centuries.

The book raises the right questions about plantation systems, but its impact is reduced by an attempt to construct world-wide coverage of an inadequate data base. It is best on the problems of sugar and bananas in Caribbean islands and enclave economies. Two appendixes include a useful survey of the relative importance of plantations around the world and a description of management structures and chains of command in sample plantations. It is regrettable that the discussion of the plantation system in the U. S. South is based almost entirely on studies and data from the 1930's. The monumental changes in the old U. S. plantation South since World War II are virtually ignored. This has deprived the book of an analytical thrust that could have strengthened its prescription for the future of plantation areas.

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Boulding, Kenneth E., and Tapan Mukerjee, eds., *Economic Imperialism*, Ann Arbor, The University of Michigan Press, 1972, xviii + 338 pp. ($10.00 cloth, $3.95 paper)

This book contains a collection of articles, with an introduction to the volume written by Boulding. The first half consists of eight articles on "concept and theory"; the lead-off article in this series is Hobson's classic "The Economic Taproot of Imperialism," originally published in 1902. Other articles follow more or less in chronological order, including a section from Schumpeter's *Imperialism and Social Classes,* and concluding with "Notes on the Theory of Imperialism" by Baran and Sweezy. The second half of the book contains seven "case studies," including several on British policy, the case of Japan, Russian imperialism, and concluding with Bronfenbrenner's "Burdens and Benefits of Empire: American Style." The book contains a useful bibliography compiled by Mukerjee. These articles are quite independent and can be read in any order. However, for a person totally unfamiliar with this literature, it will certainly be helpful to read the concept and theory selections before the case studies.

"Economic imperialism is a foreign policy that seeks political and economic control over backward areas to guarantee an outlet for idle savings and surplus manufactured goods in exchange for strategic raw materials" (Blaug, "Economic Imperialism Revisited," p. 143). As the book makes clear, much of the debate over the years has focused on one basic question: Is the motive force undergirding imperialist policies economic or political in nature? In the Marx-Hobson-Lenin interpretation, it was entirely an economic phenomenon, especially the great push and competition for colonies among European powers after 1870. Yet according to Fieldhouse ("Imperialism: An Historiographical Revision," p. 122), "The real break in the continuity of nineteenth century development—the rapid extension of 'formal' control over independent areas of Africa and the East—was a specifically political phenomenon in origin, the outcome of fears and rivalries within Europe."

Another issue running through much of the inconclusive argumentation in this literature is whether or not imperialism was actually economically beneficial to the "Center." Hobson himself believed that the gains from imperialism were a delusion. It is noted by Boulding and others that the abandonment of empire has often been followed (post Second World War) by substantial increases in the rate of economic growth. Some, on the other hand, argue that while neither governments nor national economies may have benefitted, profits of empire did accrue to specific groups within the imperialist country. And these groups—the capitalists, the industrialists, and the bankers—control the levers of political power. But this still begs the question: Why were empires dismantled even when these groups retained their power? In the current debate, an answer to this question is offered in the form of the mechanisms of "Neo-Imperialism." "Neo-imperialism does not depend upon formal political domination. It can be implemented through International organizations such as the International monetary fund which may act as the colonial administration entrusted with the responsibility of enforcing the rules of the game" (editors' forward to Balogh's "The Mechanism of Neo-Imperialism," p. 275).

"The word 'imperialism' is one of those linguistic casualties which has been drained of much of its intellectual content by its use as an arouser of emotion in propaganda battles" (Boulding, p. ix). Such a word, "which can be used to describe almost anything which the author does not like, tends also to become imperialistic and to claim areas of the social system far beyond its original meaning" (Boulding, p. x). Schumpeter, writing in the second decade of this century, said much the same thing: "The word 'imperialism' has been abused as a slogan to the point where it threatens to lose all meaning . . ." (Schumpeter, "On Imperialism," p. 36). How did its meaning become so distorted? Apparently, according to Whitney ("Russian Imperialism Today"), by the communists who endowed the word "with a special meaning." "One obvious advantage of the Lenin definition of 'imperialism' ["the monopolistic stage of capitalism"] . . . is that it obviously can only apply to the 'dirty capitalists' and never to communists" (p. 266).

The above points (and quotations) are not intended as a criticism of the book. They are meant to highlight a bit of the flavor of what is actually an excellent collection of articles. It is refreshing to read some of the older, theoretical pieces. They convey a sense of history and politics as well as insights which are usually lacking in today's literature from the left.

The one disappointment I felt after reading this collection was that there is scarcely a mention of the multinational corporation. Only Baran and Sweezy deal with this issue directly, and on a very general level, while Balogh makes indirect reference to it in discussing various neo-imperialist mechanisms. Several good analytical pieces of specific cases (such as ITT) would add an important element. Despite this weakness, however, bringing this group of articles together under one cover is an important contribution. It should be of great interest to students of economic history and development.

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Carnoy, Martin, *Industrialization in a Latin American Common Market*, Washington, D.C., The Brookings Institution, 1972, xxv + 267 pp. ($8.95)

Yudelman, Montague, and Frederic Howard, *Agricultural Development and Economic Integration in Latin America*, London, George Allen and Unwin Ltd, 1970, 336 pp. ($16.25)

These two studies, with contrasting styles and analytical approaches, are efforts to foster greater understanding of the issues faced in achieving Latin American economic integration. The volume prepared by Martin Carnoy presents the results of an empirical investigation of the potential welfare gains to members of the Latin American Free Trade Association (LAFTA) from regional industrial production, compared with producing nationally or importing from the U. S. Montague Yudelman, in a more discursive and avowedly broad-brush manner, strives to delimit the major problems and advantages of integration of the agricultural sectors of LAFTA's member countries.

The theoretical arguments underlying Latin American economic integration seldom have been buttressed by sound empirical analysis. Unfortunately, these studies, designed to help fill this need, arrive at a time when U. S. interest in Latin American economic development has dipped and when other concerns of LAFTA countries have slowed progress toward achieving regional integration. Even so, the need remains for serious analysis of the problems and potential of a coordinated regional approach to industrial and agricultural development. To this end, these two books are a welcome addition to the materials available on the subject.

The book prepared by Martin Carnoy, *Industrialization in a Latin American Common Market,* is important not only for the substantive results reported, but for the manner in which the research was conducted. Since 1963, under the able leadership of Joseph Grunwald, a number of major economic research institutions in Latin America have joined forces with the Brookings Institution to undertake research on Latin American economic integration. This collaborative effort is known as ECIEL, the acronym for its Spanish name, Estudios Conjuntos sobre Integración Económica Latinoamericana. This book presents the results of the first study undertaken by ECIEL, which, under the technical coordination of Carnoy, involved the participation of staff members of 11 Latin American institutions (from 10 countries) and the Brookings Institution.

The specific objective of this project was to determine, on the basis of economic considerations alone, the optimum size and location of plants in selected industries within a regional common market in 1975, and to estimate the potential benefits from such integration. Recognizing that it would be increasingly difficult for individual Latin American countries to substitute domestic production for imports once the stage of light manufacturing is passed, a decision was made to focus attention on products of the capital goods and heavy industries, for which economies of scale and interindustry effects could be expected.

The final choice of industries and products necessitated some compromise because of time limitations, data problems, and interest of collaborating institutions in working on studies relevant to their respective countries. Balancing these factors, a selection was made of fourteen products in six industry groups —nitrogenous fertilizers, methanol and formaldehyde, tractors, lathes, dairy products, and paper and pulp. Investigation of each industry was divided into four stages: projection for each LAFTA country of the 1975 demand levels for the 14 products; estimation of the costs of production in various countries; estimation of transportation costs within the region; and incorporation of these demand and cost estimates, along with other factors such as exchange rates, in a linear programming model to calculate the optimum (minimum cost) plant locations in LAFTA to satisfy projected 1975 demands.

The Carnoy volume is systematically organized, presenting in Part I general background on theory and the historical setting of Latin American economic integration (Chapter 1) followed by a summary of the objectives, methodology, and results (Chapter 2). Detail on each of the six industry case studies is to be found in Part II, Chapters 3–8. The methodology employed is more fully discussed in Part III, Chapter 9 and appendices.

This was an ambitiuos project, and Carnoy and his colleagues are refreshingly candid in pointing out the many difficulties faced in molding an interinstitutional effort to achieve the complex task of generating comparable data. Estimating production costs was particularly troublesome. Although demand projections were made for all countries, coverage of production costs depended on the interest of the participating institutions in making the necessary estimates. It could be argued that interest would be highly correlated with the economic potential of an industry in a particular country, but the final results were undoubtedly weakened by the inability to obtain more uniform coverage.

Estimates of total costs to the region implied by the optimum location solutions were compared with two alternatives: imports from third countries (represented by the U. S.) and autarkic production by Latin American countries (national production utilized for those countries with cost studies and imports from the lowest cost source within LAFTA when data on national costs were not available). Use of the U. S. as a proxy for extra-regional import sources appears to be generally appropriate, with the exception of tractors. Use of optimum locations as supply sources when country cost data are not available, however, could be expected to bias downward the estimates of welfare costs of autarkic production. The summary results (presented in Tables 2–4, pp. 52–53) indicate that utilization of optimum Latin American production points would be significantly superior to autarkic production, and also that the formation of a customs union would allow Latin America, in general, to compete successfully with imports from the U. S. The largest gains to the region are in nitrogenous fertilizers, lathes, and paper and pulp. Gains to LAFTA from buying from the optimum locations in the region, rather than importing from outside the area, are negative for powdered milk (but positive for cheese).

Carnoy and his colleagues are rightfully cautious in attempting to draw policy conclusions from the analysis, given the data limitations and the partial equilibrium framework possible in dealing with only a few industries, but it does appear that a Latin American customs union could be expected to benefit, albeit unequally, the large and middle-sized Latin American countries. Further, the analysis should allay some apprehensions of the likelihood of undue industrial concentration in a relatively few countries since the optimum solutions do not indicate that any country has an absolute advantage in more than two of the six groups. And further, in four of the six groups studied, the cost of a number of sub-optimum solutions with wider country participation are very close to the optimum solution.

A number of policy implications and questions are suggested by the analysis, and it is to be hoped that the ECIEL group and others will make further use of the empirical results for the guidance of policy-makers. I would also add that one of the most valuable contributions of this research study has been the attention to building of professional capacities in Latin America to perform analysis of policy-relevant problems.

Montague Yudelman's study, *Agricultural Development and Economic Integration in Latin America*, is one of a series sponsored by the Inter-American Development Bank to stimulate interest in Latin American integration and to lay the basis for action to accomplish this objective. In the foreword, Felipe Herrera notes the Bank's concern that attention on Latin American integration has concentrated on the industrial sector and on basic physical infrastructure projects, with scant attention to the role of agriculture in the process.

The book is divided in three sections. Part I is largely devoted to descriptive material on the state of agricultural resources and production in Latin America. Yudelman concludes that it should be technically feasible to accelerate rate of production increase from the historic average levels of 2 to 3 percent to 4 or 5 percent. It is argued, correctly in my view, that the major constraints on such expansion lie in the policy realm.

The central topic of the book is covered in Part II, while Part III is more of an appendix presenting a history of LAFTA with special reference to agriculture and a case study of wheat as an import-substitution possibility. Yudelman's review of the role of agriculture in Latin American development shows that (1) agricultural exports are a major source of total export earnings, (2) exports of agricultural and nonagricultural products are in the main to non-LAFTA countries, and (3) LAFTA countries have a substantial export surplus from their agricultural trade. Although intraregional agricultural trade is only a small part of the region's total trade, agricultural products comprise a significant portion of trade within the region.

Perhaps the most important part of Yudelman's argument is not what integration can do for agriculture, but what problems agriculture will pose for more general economic integration. Yudelman's conclusion is that integration of the agricultural sectors will require a harmonization of agricultural price policies and country development plans. Although there is certainly no easy solution to the problems faced in reconciling disparate national policies, Yudelman suggests a variety of short- and medium-term measures to increase trade—such as standardization of quality controls, improved exchange of market information, and perhaps the development of some system whereby preference is given to regional production to satisfy incremental demand in any one country. Yudelman also recommends a concerted attack on lowering and reducing the distortions of input prices, particularly of fertilizers and farm machinery.

Yudelman's analysis covers a broad range of topics and, although the argument tends at times to wander, is a useful summary of issues and problems faced in achieving accelerated Latin American agricultural development. It points up, however, as I am sure Yudelman would agree, the need for serious analytical research on the structure and performance of agriculture of the individual countries, if there is to be any reasonable prospect for harmonization of policies and, at some point in the future, anything resembling the creation of a common market.

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Gittinger, J. Price, *Economic Analysis of Agricultural Projects*, Baltimore, The Johns Hopkins University Press, 1972, viii + 221 pp. ($10.00)

This book is addressed to "those people in developing countries who have responsibility for spending scarce money on agricultural development." It should reach them effectively. It is a modest introduction to capital budgeting as applied to project preparation for economic development. The book will be most useful for those who prepare project plans. It will also be useful for those who in evaluating projects find themselves pressed in communicating with those who prepare project plans. Others will find the book useful: persons in economic development who lack preparation in capital budgeting; and persons well equipped in capital budgeting methodology who are searching for ways to apply it in economic development. Finally, it will serve as a primer or review focus for those who are committed only slightly or infrequently to problems of project evaluation in economic development.

Consistent with practice of the World Bank and others, Gittinger proposes the internal rate of return (IRR) as the most appropriate criterion for evaluating project proposals: the rate of discount that equates the present value of net cash flows with zero. He considers also a benefit cost ratio (BCR) and a net present worth (NPW). BCR is found wanting. It discriminates against projects in which both gross benefits and operating costs are relatively high. It is also difficult to avoid arbitrariness in assigning costs between numerator and denominator of the ratio. Both IRR and NPW avoid the "netting" problem of BCR. IRR has two further advantages: the rate of discount is "solved for" in the evaluation of cash flows, and also provides a means for ranking projects. NPW requires an assumption on a proper rate at which to discount the cash flows, and provides no basis for ranking. No mention is made of the difference in decision that can arise from the assumption implied on the earnings rate for reinvestible surpluses generated as the project materializes. So long as IRR equals the discount rate chosen in NPW, the choices will be the same. But if IRR differs from the chosen discount rate, the criterion can affect the decision [2].

The author distinguishes economic evaluation from financial evaluation. In the former, he suggests an internal rate of *economic* return (IRER); in the latter, an internal rate of *financial* return (IRFR). IRER is emphasized in most of the book. The cash flow to be evaluated in IRER is the expected gross returns less the cost of inputs valued in market or "shadow" prices, whichever is most relevant for the nation's economy. Taxes and subsidies are regarded as transfers and do not enter the evaluated cash flows. Nor does interest on capital, since it, too, is internal with respect to the national economy. Hence IRER has no distributional implication. It is a measure to reflect the effect of the project on total income produced in the nation's economy.

In contrast, IRFR is generated by a cash flow in which market prices are used to evaluate inputs. Taxes (as costs) and subsidies (as returns) are included. Interest paid on borrowed funds are deducted as are principal payments. (Loan proceeds are included as cash inflows.) IRFR is relevant to a specific participant in the system. Financial evaluations are needed to reflect different effects of a project among system participants; to provide clues on responses that might be expected among participants to opportunities created by the project; and to suggest modifications in the project to reduce inequities revealed among participants modeled in financial evaluations. Ciccheti *et al.* [1] have criticized a procedure proposed by the Water Resource Council [3] to introduce into project evaluation weights that would reflect differential effects of development projects. Gittinger's simple distinction of IRFR's to supplement an IRER might be suggested as a practical alternative.

In his discussion of financial evaluation, Gittinger found it possible to introduce leverage (which he defined as the ability of a decision maker to change IRFR through use of borrowed capital). As a footnote, we might suggest that he as easily could have introduced the complementary concept of liquidity (the ability to generate cash from sales or borrowing). As leverage is gained, liquidity is lost. Clearly there is an equilibrium in decision behavior that governs the use of credit within decision units. To have explored fully the issues thus revealed would have carried the book beyond its modest scope. Yet to have introduced but half the concepts necessary to the appropriate analysis may be a questionable contribution.

Minor flaws can be found. The author observes that to use as a discount rate "the borrowing rate for the project to be financed . . . has the undesirable result . . . that the selection of projects will be influenced by the financing terms rather than . . . their relative economic impact," p. 61. Yet on page 63, he concludes that a "benefit-cost ratio . . . less than one [means] it would be better to put the money in a bank at the assumed interest rate than to invest it in the project." The single excursion into algebra is made on page 98. But alas, the index of summation and the subscripts do not match in the expressions for the benefit-cost ratio, the net present worth, and the internal rate of return.

On the whole, the book is remarkably lucid and free of needless jargon. Sensible suggestions are found on prices to use for land and labor and on problems of inflation and foreign exchange. Costs and benefits are identified and discussed in some detail. In controversial issues, the author takes a forthright position, making it clear that alternatives exist. An example is found in a brief explanation of the Little-Mirrlees method for valuing goods and services in preparing project plans. Some topics clearly lie outside the scope of the book. A brief but well chosen set of references are provided and referred to at appropriate points in the text. Evaluative comments are provided for most references.

The author makes liberal use of project examples to illustrate the use of methods he describes. They are useful complements to the text. One minor criticism: no index is provided. Even though the book is brief, its purpose is methodological. This user would have found an index useful.

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References

[1] CICCHETI, C. J., *et al.*, *Benefits or Costs? An Assessment of the WRC Principles and Standards*, Department of Geography and Environmental Engineering, The Johns Hopkins University, March 1972.

[2] VAN HORNE, C., *Financial Management and Policy*, Englewood Cliffs, Prentice-Hall, 1968.

[3] U. S. Water Resources Council, "Proposed Principles and Standards for Planning Water and Related Land Resources," *Federal Register* 36:24144–24194, 1971.

Houck, James P., Mary E. Ryan, and Abraham Subotnik, *Soybeans and Their Products*, Minneapolis, University of Minnesota Press, 1972, ix + 284 pp. ($10.00)

This specialized book is an expansion and consolidation of previously reported economic research on soybeans conducted at the University of Minnesota. The report is organized into three major parts: the first provides meaningful descriptive and diagnostic information to support the second part containing the econometric model, the quantified demand-supply structure, and the modified bases for policy evaluations, while the third part presents a detailed breakdown of the foreign demand components. Very few technical errors were found, but an inordinate and troublesome time-gap between the data period (1946–1967) and the publishing date (October 1972) is evident. Undoubtedly both researchers and publisher are to blame for the failure to be more up-to-date.

The authors reach two major conclusions and with a considerable amount of justification. First, they propose that logical and relevant approximation models can be specified and quantified for complex sectors of U. S. agriculture and that this study is a good example. Secondly, they contend that decisions on production and marketing in the private sector and on public policy action programs can be improved and discussed more objectively by means of these quantified relationship systems than by less analytic information bases. These conclusions are in accord with the productivity of the scientific method, and I concur in supporting such viewpoints. However, in spite of many excellent aspects of the analytic sections of this book, there are enough questionable issues on structure and measurement methodology to defer a judgment on the projective utility of this report. The old adage, "the proof of the pudding is in the eating," when applied to quantified economic models is by the projective performance outside the data period (unless dynamically recomputed and recursive) and not necessarily by measures of "goodness of fit" within the data period.

Many excellent examples of the scientific artfulness of the authors in approximation model building (the practical union of economic theory, measurement methodology and logical simplification) are to be found in the second part of this book. The logical separation of demand and supply forces and the treatment of independent or substitution elements relating to each are handled well. Several mathematical adjustments to surmount nonlinearities and to secure estimates of the dynamic results stemming from specific policy instrument changes are presented with clarity. Students and research workers interested in quantitative analysis should learn many practical procedural concepts from this report. The soundness or likely stability of future performance applications of the estimated foreign demand functions in part three do not reach the quality of the work in the second part of the report.

While reviewing a technical publication of this type, one continuously evaluates the material for commendable content and also challenges specific issues with his own judgment of alternative or more logical approaches. On occasions, an error in logic or methodology can arise. Without striving for any specific ordering, I will list points and procedures which I question in this study. Some of my suggestions of alternatives would have been stymied by lack of directly available data.

1. Usage of "effective support prices" in the supply analyses in single aggregate response functions (by regions) could result in parameter estimates which are "neither fish nor fowl" for differentiated subgroups of producers (compliance vs. noncompliance) and under large differences in yield and net revenue trends between crops over the data period.

2. CCC stocks were considered exogenous and soybean prices endogenous in model specification and quantification. Later, in policy evaluations, they were switched for appropriate cases related to support price levels versus market prices. It seems that a data period with mixed yearly cases of open market and effective support prices (significant CCC stock accumulations occurred in 3 to 5 years during 1946–67) requires separable groupings for proper estimation processes consistent with random variable con-

cepts. Usage of dummy variable options might be a way out when dynamic links are implied by lagged variables and therefore require a continuous data format.

3. Differentiated response parameters for supply relations (and some demand components) should have been specified for level of CCC stock and directional changes thereof.

4. The three cases relating price support levels to potential or realized open market clearance prices and release price level provisions could have been handled more clearly by direct reference to the comparative static demand and supply diagrams implied on p. 71 instead of the partial relationships given on p. 106 and following. The questions of what levels of price support would be associated with which cases and the implied consistent changes in CCC stocks would have been more directly answered as well as the limits of price support changes for policy evaluations.

5. In my judgment, an inadequate specification of the interrelationships between practical decisions on price support levels, the release price specifications, and the experienced accumulation of government stock was used. This has a bearing on some of the policy evaluations (implicit independence of release price specifications) as well as structural equation estimates.

6. Single price supports (when effective) have umbrella effects for competitive substitutes in production or utilization. Separable additive effects should not be implied for support program changes under these conditions. Corn, oats, and perhaps wheat were involved in this study. Had grain sorghum and barley been included, the implication would have been more serious. Consistent market price changes will occur independent of price support changes for all the products.

It should be a severe test for the performance stability of the estimated functions of this study to evaluate them for the 1968–72 period. Early large surpluses and then intensive movement to open market conditions in 1971 and 1972 provide extreme cases.

Finally, I would recommend this book for quantitative and policy oriented research workers and all others directly involved in the dynamic soybean sector.

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Imel, Blake, Michael R. Behr, and Peter G. Helmberger, *Market Structure and Performance: The U. S. Food Processing Industries*, Lexington, D. C. Heath and Company, 1972, xv + 115 pp. ($10.00)

This small book is the latest and one of the more successful attempts to show empirical relationships between market structure and performance. The research it reports dealt with a sample of 99 medium-sized and large firms primarily engaged in the food and tobacco manufacturing sectors of the economy (SIC's 20 and 21). Original data were collected from the firms to supplement published information; inability to obtain data from some firms limited the size of the sample.

Rather than forming and working with aggregates for industries (e.g., 4-digit SIC groupings), the authors treated each firm as a separate observation. In an analysis of one aspect of performance, for example, each firm's profit rate was considered to be a function of 4-firm concentration (a market-related variable) and of advertising and R and D expenditures (firm-related variables). Since most firms operated in more than one market, concentration was measured for each firm by weighting the 4-firm concentration ratios in the markets in which it participated by the firm's sales in those markets. A well-known study by the Federal Trade Commission used a similar approach.

As the authors show, there is good reason to expect that error covariances will not be zero when this procedure is used and that heteroskedasticity will exist as well. A feature of the research is the meticulous attention given to the implications of this for estimation procedures. Both generalized least squares and ordinary least squares estimates are presented. The analysis is extended to errors to be expected when industry and sector aggregates are used and shows that the assumptions underlying ordinary least squares may not hold.

Industries were defined for the purpose of measuring market concentration by starting with 4-digit and 5-digit SIC groupings and by further adjusting many of them by adding or subtracting certain subparts. In addition, concentration ratios in local markets rather than in the national market were used for fresh milk and soft-baked goods. Other industry classifications, including the standard 4-digit SIC industries, were used in the analysis to test the sensitivity of results to market definitions.

The authors chose as their preferred measure of profits net income after taxes, minus an implicit return of 5 percent on equity capital, expressed as a ratio to sales. If concentrated industries tend to have low capital turnover, which may be the case, choosing the right rate of return on equity would be crucial to avoiding misleading results, but no justification for 5 percent was offered. It seems too low for equity capital in the 1959–67 period. Alternative measures of profits were also used, however, and results were generally consistent with, if weaker than, results for the measure the authors liked best.

The authors conducted their analysis and stated their conclusions conservatively. They found strong support for the hypotheses that profits are positively related to market concentration, to product differentiation as represented by advertising expenditures, to R and D expenditures, and to relative size of firm. They employed an ingenious method from which they concluded that the relation of profits to concentration is linear, though the reader may argue that there is a kink where the concentration ratio is about 35 percent. Similarly, they found that progressiveness of firms as represented by R and D expenditures appeared to be positively related to market concentration, diversification of the firm, and perhaps to product differentiation and to nonfood sales as a proportion of total sales.

Many economists would ask the authors to dip their toes into deeper water. Is there interaction between concentration and product differentiation in effects on profits? Is the effect of concentration on profits large enough to be socially as well as statistically significant? If concentration increases both profits and progressiveness, are we faced with a trade-off between the two? May profits, concentration, product differentiation, and R and D be mutually interrelated in complex ways not suggested by the unidirectional models? One could scarcely ask the authors to extricate the wild duck in a line quoted by Keynes, "The wild duck has dived down to the bottom—as deep as she can get—and bitten fast hold of the weed and tangle and all the rubbish that is down there, and it would need an extraordinarily clever dog to dive after and fish her up again," but the authors did so well what they undertook to do that one wishes they had gone a little further into the tangle.

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Ironmonger, D. S., *New Commodities and Consumer Behavior*, New York, Cambridge University Press, 1972, xviii + 200 pp. ($19.50)

Part I of this book is basically concerned with extending consumer behavior theory to handle new commodities and changes in tastes and product qualities. Consumer preferences are defined in terms of well-ordered wants which are in turn related to commodities via a consumption technology. This theoretical structure is similar to the one developed by Lancaster [1]. The differences between these two theories are noteworthy. Whereas Lancaster's model maximizes the attainment of commodity characteristics subject to the consumption technology and budget constraints, Ironmonger formulates the choice problem as a linear program in which the marginal want is maximized subject to the satisfaction of certain prior wants and the budget constraint. While there is not necessarily a unique optimum budget in Lancaster's model, Ironmonger's model gives in most cases a unique optimum budget because the consumer is assumed to choose commodities that most efficiently saturate his wants in the order of their priorities. While unique solutions facilitate empirical analysis, the behavioral implications of this assumption can be quite restrictive, especially when dealing with individual commodities. Consider the example (p. 27) of water serving two wants: thirst and cleanliness. When the consumer's income does not enable him to attain his saturation level for thirst, the consumer uses water only to quench his thirst. Presumably, the consumer forsakes cleanliness until his saturation level for thirst is achieved. In addition, the determination of the priority ordering among wants can be quite arbitrary as evidenced by example 2.7.2 (pp. 43–45) where the priorities among five food nutrients representing wants are defined by ranking these nutrients according to their average consumption levels. While the author maintains that the choice consequences of ordered priorities is crucial only at lower levels of real income (p. 24), choice behavior will also be affected at higher income levels since the number and saturation levels of wants usually increase with income. Certainly, a consumer can have saturation levels for ordered wants without satiating these wants in the order of their priorities. However, this less restrictive assumption would undoubtedly eliminate the chances of obtaining a unique optimum budget.

Building on this basic theoretical framework, the author defines changes in consumer tastes as an alteration in the saturation levels for and priorities among wants, and changes in product qualities and the introduction of new commodities in terms of changes in the consumption technology. He then proceeds to analyze individual and group purchase response, specifically Engel and demand curves, to changes in tastes, product qualities, income, prices, and the introduction of new commodities. Although the individual relations are discontinuous, aggregation to group relations smooth out the discontinuities.

The connection between the theoretical developments of Part I and the applications in Part II is quite weak. Applications are primarily limited to a consideration of the importance and role of new commodities and quantification of the diffusion process for new commodities. A useful distinction is made between eight stages of a commodity's life cycle. By applying ordinary least squares to lag-sequence observations on the consumption of 113 commodities in the United Kingdom, the commodities are classified into the appropriate life-cycle stage. Using 1920–38 British data on 25 commodities, the diffusion, price, and income effects on consumption are estimated by regressing consumption per adult equivalent on seven combinations of real income per adult equivalent, real prices, and one-period lagged consumption. Results support the basic hypothesis that a significant proportion of the variation in the consumption of new and outmoded commodities can be attributed to the diffusion process. In the new and outmoded stages, the diffusion effects appear to be as important and in some cases more important than price and income effects. One-period lagged consumption is included in the regression equations to represent the effects of diffusion. The author maintains that the coefficients of lagged consumption should not be interpreted as lag responses to changes in prices and income. However, this proposition is in the form of a conjecture (no formal tests were made), and it is possible that the coefficient of lagged consumption also reflects a partial adjustment effect. In fact, the logic behind the partial adjustment hypothesis, i.e. that consumers have certain habits and purchase patterns that cause the complete purchase response to price changes to be distributed over an extended period of time, is not inconsistent with the rate of diffusion of a new product.

In summary, this book provides a fresh theoretical explanation of consumer purchase response to new commodities and changes in the qualities of existing commodities and consumer tastes. Although one may take exception to Ironmonger's conception of how want priorities affect consumer behavior (one cannot seriously deny their existence), this conception seems less restrictive when dealing with groups of commodities than with individual commodities. Furthermore, well-ordered wants provide unique deterministic solutions to the consumer choice problem. Analysis of the diffusion process for new commodities should prove quite useful in explaining the variation in the consumption of new and outmoded commodities not explained by price and income changes. The latter has heretofore been treated as an unexplained residual. This book will undoubtedly become an important reference for the consumer behavior theorist and analyst.

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Reference

[1] LANCASTER, KELVIN, *Consumer Demand: A New Approach,* New York, Columbia University Press, 1971.

Johnson, Glenn L., and C. Leroy Quance, eds., *The Overproduction Trap in U. S. Agriculture: A Study of Resource Allocation from World War I to the Late 1960's,* Baltimore, The Johns Hopkins Press for Resources for the Future, 1972, xvii + 211 pp. ($10.00)

Under the auspices of Resources for the Future, Johnson and Quance have put together the work of eight writers in support of the asset-fixity hypothesis concerning agricultural supply which Johnson has propounded continuously since 1958. Part I written by Johnson consists of four short chapters concerned with theory. Part II, containing five chapters, reports research developed by seven Michigan State graduate students primarily as dissertations written in the mid-1960's. For the most part the empirical research has not been published elsewhere. Part III contains a chapter which purports to summarize the results of the earlier chapters chronologically and a chapter in which Johnson urges the development of policy to reduce resource waste in agriculture. There is also a mathematical appendix which develops some of the diagrams and calculus for Part I.

In broad terms, the major hypothesis is that agricultural supply functions have different slopes for price increases and decreases. Propounded 40 years ago by Cassells [1], few economists would quarrel with this proposition for some lengths of run. In more specific terms, the hypothesis put forward in the book is that resources are mistakenly committed to agriculture in such volume that prices are depressed and farmers fail to recover investment outlays. Further, the malady is so serious and repetitious as to justify remedial action. Few economists are likely to be convinced of this proposition for four reasons. First, the theory utilizes such asymmetrical assumptions concerning the impact of time on the organization of production as to make the theory unattractive. Second, so little attention is given to the formal structuring of tests to discriminate between this theory and its competitors that it is difficult to know when one or more of the competitive theories would be regarded as superior to the asset-fixity theory. Third, the empirical work does not confirm the predictions. Fourth, the policy recommendations are not based on an estimate of either the benefits or the costs of the proposed action. These points are developed below.

Three propositions are combined to construct the basic model of overproduction: (1) in the presence of uncertainties and of inputs embodied in stocks, *ex post* errors in farm use of inputs will occur; (2) once these errors are recognized, the existence of transaction costs leads to two prices (acquisition and salvage), and the lower salvage prices bias adjustment in the direction of more output; (3) desired increases in factor use can be made instantaneously even though decreases require time. Most economists would find the first two propositions plausible. But by themselves, unrelenting overproduction is not a necessary result. Suppose that errors in the initial organization were such that without reorganization aggregate receipts would be at or above the level consistent with errorless competitive equilibrium. If time is required to adjust resource combinations after price expectations are revised, farmers will be unable to overproduce in some periods. Only if adjustment to initial errors is instantaneous and costless, will overproduction necessarily prevail. Yet if adjustments can be made instantaneously (proposition 3), there is no reason to risk making mistakes (proposition 1). This conflict essentially invalidates the theory.

The second problem relates to the structuring of tests of hypotheses. Several theories predict that income may fall below opportunity costs from time to time, at least for some firms (D. G. Johnson, [3]; Cochrane, [2]; Tolley, [4]). Consequently, some formal test should have been derived to distinguish between the competing models, but little attention was given to this problem and no precise tests were developed.

The third difficulty is the failure of the empirical evidence to agree with the predictions. On balance nominal capital gains, not losses, were realized on physical capital (Tables 13, 14 and 15), while capital losses were estimated for expendables (purchased annual inputs, Table 16). Clearly this is the reverse of the predictions. In considering labor, no direct test of the effect of on-the-job training of veterans was made. While the relationship between FHA-FCA loan capital and entry was studied, the regression provided for no estimate of the displacement of commercial credit. Thus the net effect of FHA-FCA credit on entry remains unknown. One study concludes that there was little net change in the land stock between 1920 and 1970: a finding that does not tend to support the theory. While some space is given to discussing the possibility that "unduly" high land prices will lead to increased nonland input use, no evidence is presented.

The fourth difficulty lies in the manner in which policy conclusions are reached. More central direction of the agricultural sector is urged in a concluding chapter. However, no estimate of the cost of making controls effective is reported. Clearly, implementing effective controls on either inputs or on output would be costly. No estimate of the level of benefits which would flow from such a policy is introduced. Consequently, the final conclusion must be that the goodness of the advocated policy in terms of GNP, let alone welfare, is unproved.

A number of topics not central to the theory are discussed in the book, among them the size distribution of firms, the use of welfare economics, and objectivity. Some readers will find these interesting, but the exposition is encumbered by special definitions and interpretations. Perhaps the high point of the book found in Chapter 6, is the excellent description, not analysis, of changes in U. S. agriculture since World War I.

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References

[1] Cassells, John M., "The Nature of Statistical Supply Curves," *J. Farm Econ.* 15:378–387, April 1933.

[2] Cochrane, W. W., *Farm Prices Myth and Reality*, Minneapolis, University of Minnesota Press, 1958.

[3] Johnson, D. G., "The Nature of the Supply Function for Agricultural Products," *Am. Econ. Rev.* 40: 539–564, Sept. 1950.

[4] Tolley, G. S., "Management Entry into U. S. Agriculture," *Am. J. Agr. Econ.* 52:485–493, Nov. 1970.

Merewitz, Leonard, and Stephen H. Sosnick, *The Budget's New Clothes: A Critique of Planning-Programming-Budgeting and Benefit-Cost Analysis*, Chicago, Markham Publishing Company, 1971, xi + 318 pp. ($10.95)

The Budget's New Clothes is both exposition and criticism; it is not a research monograph. While not a conventional text, it is likely to be adopted in some upper-level undergraduate public finance courses and graduate courses in public policy or public administration programs. The volume has two distinct parts. The first part (Chapters 1–5) is a description of the structure and evolution of the federal government planning-programming-budgeting system and a critique of its effectiveness. The second part (Chapters 6–12)) is an exposition of the theory of benefit-cost analysis and a critique of its application to federal government programs.

In Chapters 1–5, the antecedents of PPBS are traced and the non-analytical components of the recent federal system are described and then subjected to a benefit-cost type evaluation. The four components discussed are program accounting (program budgeting), multi-year costing (budget projections), detailed description and measurement of activities (program memoranda), and zero-based budgeting. In general, the overall evaluation of these parts of the system is strongly negative: the costs—in the form of staff time and effort, reductions in the flexibility of government, and "political" sacrifices—are judged to be in excess of the benefits—better decisions attributable to "enlightenment," coordination, elimination of overlapping and redundant activities, and increased accountability.

The mode of evaluation and critique undertaken in these chapters is impressionistic. Like so much writing about the impact of systems of public decision-making and budgeting, the conclusions of this part of the book are based on personal predilection, supported by references to the writings of other, like-minded observers. With few deviations, the perspective reflected in this part of the volume is that of the "muddling-through" school represented by Wildavsky and Lindbolm. This representation of the public decision process emphasizes the "political opportunity costs" (as Charles Schultze has termed them) of efforts to force a specification of objectives, the gains of an incremental approach to decision-making, and the importance of the advocacy process in reaching decisions. Such a pragmatic approach stands in stark contrast to the rational, problem-solving, long-term planning approach characterized by the PPB system. In my view, this movementalist perspective neglects the gains which PPB does convey through the discovery of other neglected policy alternatives and the clarifying of value judgments on which policy decisions must rest. However, given this perspective, it is not surprising that the authors' evaluation of the PPB system is adverse.

In this first one-third of the book, the authors give only passing reference to the centralization of power and authority within the Executive branch of government attributable to the PPB system. In fact, this may be one of the most significant—and costly—impacts of the system. Related to this is the complete neglect by the authors of the contribution of the PPB system to the shift of policy and decision-making initiative from the Congress to the Executive branch. The PPB system was created by the Executive for the Executive. None of the studies or analyses undertaken have been made available to the Congress, which is left to question weakly and then to ratify. As a consequence, the power which information and evaluation affords has accrued only to the Executive, aggravating still further the disparity between the two branches in the knowledge of what government does and how it does it. Reflecting the Executive branch bias of the PPB system itself, the authors do not so much as mention the legislative branch until page 56, and then only in passing.

In the second part of the book, the discussion switches from the practice of the PPB system to the theory and application of benefit-cost analysis. Beginning with a rather technical analysis of the welfare economic basis of benefit-cost analysis and the various criteria for project evaluation (benefit-cost ratio, internal rate of return, net benefits), the authors discuss, in turn, the appropriate treatment of time (discounting) and uncertainty, the theory and measurement of efficiency benefits, the procedures for evaluation with multiple objectives, and the estimation and prediction of costs. The final substantive chapter presents two benefit-cost analysis case studies—the California Water Project and the Supersonic Transport. In this chapter, the methodologies employed and the efficiency results are summarized and the impact of the analyses on public policy decisions is appraised. Although one of these projects is being undertaken while the other has been rejected, the authors conclude that "efficiency criteria have been largely ignored in the decisions."

Overall, I found this part of the book to be one of the best presentations of the theory and practice of benefit-cost analysis available. The analysis is substantive and is effectively interspersed with summaries of actual benefit and cost estimates and estimating procedures.

In addition to a number of quibbles on technical matters, I have three major reservations regarding this part of the volume. The first is the terseness with which some of the more complex theoretical and econometric models are presented. For example, the analysis of alternative welfare criteria (Pareto, Kaldor-Hicks, Scitovsky, Little) is presented in six pages, externalities in two pages, the Arrow-Hirshleifer debate on the appropriate treatment of uncertainty in three pages, demand curve estimation in three pages, the time-travel cost model of recreation demand estimation in four pages, the Churchman-Ackoff-Arnoff relative weight assignment method for multiple objectives in two pages, Steiner's general opportunity cost model in two pages, and the production-cost function duality in two pages. The cryptic discussion of both mathematical and econometric models displayed in these presentations detracts from the potential pedagogical use of the book.

My second reservation concerns the imbalance in the discussion of the application of benefit-cost analysis among program areas. The bulk of the discussion focuses on the evaluation of physical investments in the water resources, transportation, and military procurement areas. A total of three pages is devoted to the numerous benefit-cost studies of human investment programs, including education and manpower training, which include some of the most innovative applications of welfare economics.

Finally, the discussion of the use of "shadow prices" where market (or efficiency) prices are incorrect or unavailable is weak. The valuation difficulties created by publicly administered or monopoly prices, external effects, or unemployed resources are recognized in the benefit-cost literature, and research studies to develop appropriate shadow values are well-known. Yet the authors only mention these valuation difficulties in passing and make no reference to the research designed to develop meaningful surrogates. Citing the pessimistic stance of McKean and Prest and Turvey regarding shadow pricing, they state, "Unfortunately, there is no objective way to adjust for these imperfections" (p. 215).

In sum, I found *The Budget's New Clothes* to be a solid volume. It yields insights into both the theoretical and empirical issues confronted in applying economic analysis to government activities and the administrative difficulties in bringing such analysis to bear in the budgetary and decision-making process. Although the unevenness in the two parts of the book detracts from its overall quality, it is a competent piece of work which will be of value to both scholars and students of public expenditure economics.

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Rossi, Peter H., and Walter Williams, eds., *Evaluating Social Programs: Theory, Practice, and Politics*, New York, Seminar Press, Inc., 1972, xviii + 326 pp. ($10.95)

The volume is a collection of 13 papers dealing with the problems and procedures of evaluating social action programs such as Head Start, the Job Corps, the Negative Income Tax, etc. A major stimulus for the book appears to have been a 1969 conference "Evaluation of Social Action Programs" sponsored by the American Academy of Arts and Sciences. The lead-off paper in the book (after the overview) summarizes the conference proceedings while two of the included papers were presented at the conference itself. The remaining papers were drawn from various sources including the American Sociological Review, other conference proceedings, departmental papers, and another book of readings.

Although the book is divided into four parts, sections II and III contain the bulk of the material. Section II deals with aspects of the theory and methodology of evaluative research while the papers in section III relate to specific welfare programs. The first three papers of section II in large part argue the merits of the controlled experiment as an "evaluation design." There appears to be some confusion, however, between ways of gathering data and analytical techniques. For example, on pages 46 and 47 there is a ranking of research designs from the most to the least desired. Of highest rank is the controlled experiment, followed by correlation designs in which statistical controls are used. Yet, it seems that the former is one way of gathering information or data while the latter is an analytical tool that can be brought to bear on data whether it be gathered by a controlled experiment or another means such as census questionnaire.

Also, section II contains a critique of the Coleman Report by Glen Cain and Harold Watts. The authors criticize the Report on two counts: (1) No theoretical justification is offered for the explanatory variables included; and (2) variables are evaluated solely on the basis of statistical significance. Regarding the latter point, the authors argue that for policy purposes we should be concerned mainly with using the variables which provide the greatest gain per unit cost rather than with variables exhibiting the highest F-ratio.

Two of the papers in section III deal with Head Start, one with Federal Manpower Programs, and another with the New Jersey Negative Income Tax experiment. The latter is mainly a discussion of the "nuts and bolts" of setting up and operating such an experiment.

If diversity is a virtue, this volume should be given high marks. On the other hand, it is not likely that the volume will hold the interest of many readers over its entirety. Economists interested in the economics of education should find the Cain and Watts paper worthwhile reading. The papers contained in section II, including the Cain and Watts paper, also should prove useful to the study of research methodology. Although not explicitly mentioned, some interesting contrasts in methodology can be observed between economics, specifically the Cain and Watts paper, and the other social sciences. About two-thirds of the papers in the volume were written by noneconomists.

The papers in sections III and IV might be of interest to teachers of social science courses dealing specifically with poverty programs. The material should be easily comprehensible by Masters degree students and not above the grasp of most upper division undergraduates.

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Schultze, Charles L., Edward R. Fried, Alice M. Rivlin and Nancy H. Teeters, *Setting National Priorities: The 1973 Budget,* Washington, D.C. Brookings Institute, 1972, ix + 468 pp. ($3.50 paper)

This book is the third annual analysis of the federal budget, in the series initiated by the Brookings Institute in 1970. These analyses are made to distill out of the national budget the executive branch's assessment and decisions on national priorities. Also, since the budget is a detailed, technical, and abstruse financial complex, this book serves also to communicate implied priorities to the public in an understandable form.

Following the overview in Chapter 1, the next four chapters deal with the defense and security budget. Part II, composed of six chapters, deals with purely domestic problems relating to family income supports, health insurance, child care, fiscal problems of cities, elementary and secondary education and the environment. The four chapters of Part III include analysis and interpretation of the distribution of the fiscal dividend resulting from termination of Vietnam activities, revenue and expenditures for the future, alternative sources of federal revenue, and new approaches in establishing priorities. Overall, the book is an interpretation and evaluation of the national budget with respect to: (1) its size and the manner it is financed in relation to national output, employment, and inflation, (2) the manner in which it determines the allocation of national resources and the portion accorded to public and private needs, (3) the effects of different taxes and allocations on the distribution of real income among income groups, and (4) its comprehensive reflection of overall national policy.

The authors relate the defense budget to the administration's orientation to foreign relations and connect the Nixon doctrine to U. S.–Soviet relations, the U. S. role in Western Europe, and potential settlement of wars in Asia and the Middle East. After review of the rapid increase in Soviet defense expenditures over the period 1964–72 with expectations of large future increases, strategic force alternatives are outlined for the U. S. These alternatives suggest restraint on the part of the United States since part of the Soviet buildup is directed towards China and a two-continent war contigency, certain U. S. responses would be matched by Russia, and otherwise, resources would be drawn away from more important security and domestic needs. For the different alternatives, seven different budgets are presented for the 1973–79 fiscal years. The outlays and alternatives range from 21.2 billion dollars for no SALT agreement and an accelerated defense program, to 10.9 billion dollars for transition to dependence on a completely sea-based force. Alternative programs and budgets also are presented for ground combat forces, naval carrier forces, naval general purpose forces and tactical air forces. Reforms also are discussed for an all-volunteer army, military pay and retirement, and weapon acquisition policies. Finally, the effect of defense budget alternatives on employment in the short and long run is discussed.

Under domestic programs, the chapter on family income supports reviews the wide range of programs currently in effect, summarizes arguments for and against various programs, then evaluates alternatives such as universal vs. means payments, contributary vs. noncontributary, categorical vs. needs approaches, payroll financing and cash vs. in-kind benefits. The chapter on health services reviews current recipients of public expenditures, discusses medical care inflation and need for more professional manpower, and other facets of the existing supplies and prices of medical care. The authors conclude with a federal health insurance program which should check the escalation of medical prices and excess use of services, avoid creation of a two-class medical system, and minimize the transfer to the public budget of health costs by middle-and-upper income families —to save scarce tax resources for other high priority public purposes.

In the chapter on child care, reasons for the rapid demand increase in child care are reviewed against the supply and price of these services. This chapter summarizes a range of surveys and interpretations of the needs, nature, changes and clientele of various types of child care facilities. Proposed legislation is reviewed, but the authors do not make specific suggestions for public subsidy and regulation of day care facilities. In discussing fiscal problems of cities, the authors conclude, as others have, that difficulties experienced in balancing needs with resources will intensify in the future. Hence, by default the federal government will be required to come to the rescue. However, the fiscal problems of large cities are not likely to be thus eliminated and the federal government will have to choose between "doing it alone," or enlisting the help of the state and the suburbs. With respect to education, the usual major problems are discussed as disparities in expenditures, race and poverty, and desegregation. Alternatives are outlined for reforming property taxes, revising state school financing, attaining interstate equalization, and realizing integration.

The chapter on environment is rather general and concludes that environmental qualities are valuable resources; people now want cleaner air and water and look to the federal government for it; reducing pollutants is expensive; and both air and water are complex phenomena. In discussing alternatives and means (public and private) for controlling pollution, the authors state that nothing in the nature of air and water suggests stopping economic growth. Also, federal involvement is necessary to prevent tax controls in particular states where competitive advantage might be attained through lower industrial costs. Questions posed for new methods of establishing priorities, not only for the environment but other major dimensions of economic and social life, include a three-year budget period and certain mechanical steps in its processing.

This book is a broad survey of the nation's economic and social problems and the scarcity of resources available for solving them. In this framework it might well have been written without the excuse of building it around the budget. The budget is interpreted especially with respect to the defense budget and the projection and distribution of federal expenditures and revenues. For other major areas of analysis, the budget is much less a necessity and frequently is not a concern, of the problems reviewed, the conditions summarized, and the popular and specific alternatives suggested. Any of the major domestic problems could have been treated as thoroughly as the defense budget, which was related much more systematically and specifically to the alternatives set forth.

A stated objective of the book was to communicate the nature and meaning of the budget to the public. The public for which the book best communicates the obscured meaning of the budget probably includes intelligent and concerned public leaders, legislators, students, and social scientists. To "reach the man on the street," the volume would still need a vast distillation and reduction. The authors do, however, provide a rather objective analysis of a bounded set of alternatives relating to the federal budget. In some chapters, the biases of the particular writer tend to "show through," but the volume is of high quality and provides a commendable public service.

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Whitcomb, David K., *Externalities and Welfare*, New York, Columbia University Press, 1972, x + 158 pp. ($8.00)

Professor Whitcomb is to be complimented for a well organized and well written theoretical discussion of production externalities. The book is devoted to an analysis of the efficiency conditions and an associated set of constant amount per unit taxes or subsidies which would be Pareto optimal. A general equilibrium setting with N goods and R firms under perfect competition and no externalities in the consumption sector is employed throughout.

The basic theoretical innovation is the use of a production function which treats both salable goods and externalities as produced goods, but the externalities enter only as intermediate goods—that is, as inputs in the production relations for salable commodities. A fairly detailed derivation is provided for the cost function associated with the production function; this could have been asserted directly from duality theorems due to R. Shepherd. Derivations are a bit restrictive as are the theorems employed since the arguments rule out boundary solutions—that is, zero input or output levels. The theorems employed require open sets in their hypotheses. It should be added, though, that the limitations employed together with the rather extensive detail provided do make it fairly easy for a reader who is not familiar with mathematics to make considerable headway on his own. In addition, analytic proofs of well-known theorems such as those due to R. Coase make parts of the text quite useful even though the results are not new.

Policy oriented theoretical topics begin with a series of theorems dealing with the set of constant amount per unit taxes or subsidies which, if named as the market "prices" for the externalities, would lead to Pareto optimal amounts of goods and externalities being chosen as the result of decentralized production following a profit maximizing criterion. The theorems are developed under the assumption that one has perfect information. Although the author does not explicitly mention it, the taxes or subsidies sought are simply the dual variables associated with the externality production functions in a nonlinear program. Under the traditional assumptions of convexity for production sets and concavity for profit functions, the existence of such a set of Pareto optimal taxes and subsidies could have been directly obtained from programming theorems.

The author criticizes one of the more promising proposals for coping with the stringent information requirement employed in his work and in most of the externalities literature: the Davis-Whinston iterative scheme. The only evidence provided for the infeasibility of the scheme is the result of several simulation experiments. Once one recognizes that dual variables are being sought, the Davis-Whinston scheme can be thought of as being the well-known Lagrangian algorithm which is known from theoretical considerations to converge under the convexity/concavity assumptions employed by both Whitcomb and other writers.

A particularily interesting, and I feel promising, set of issues is raised in Appendix C dealing with tax or subsidy functions which are not linear. The importance of this topic stems from its ability to cope with nonconvex problems. This topic certainly would seem to be a fruitful area for further work.

Although two applications topics are raised in the introduction, these do not reappear until the concluding chapter where they are not pursued at length. In fairness, one must point out that the principle issues the author chose are theoretical, and these are developed well, but specific analysis of applied problems is needed to be able to evaluate fairly the usefulness of the generalized production function concepts. The author's concluding comments on the direction of further research merit a thoughtful reading.

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Books for listing in this section should be sent to the Book Review Editor (see inside front cover for address).

Books Received

Balaam, L. N., *Fundamentals of Biometry,* New York, John Wiley & Sons, 1972, xiv + 259 pp. $12.95.

Bard, Robert L., *Food Aid and International Agricultural Trade: A Study in Legal and Administrative Control,* Lexington, D. C. Heath and Company, 1972, xviii + 321 pp. $12.50.

Brown, Lester R., *World Without Borders,* New York, Random House, 1972, xviii + 395 pp. $8.95.

Buchanan, James M., and Robert D. Tollison, eds., *Theory of Public Choice: Political Applications of Economics,* Ann Arbor, The University of Michigan Press, vi + 329 pp. $15.00.

Burkhead, Jesse, and Jerry Miner, *Public Expenditure,* Chicago, Aldine·Atherton, Inc., 1971, x + 346 pp. $12.95.

Di Marco, Luis Eugenio, ed., *International Economics and Development,* New York, Academic Press, Inc., 1972, xix + 515 pp. $18.50.

Draycott, A. P., *Sugar-Beet Nutrition,* New York, John Wiley & Sons, Inc., 1972, ix + 250 pp. $19.50.

Drilon, J. D., Jr., ed., *Agribusiness Management Resource Materials* (Vol. II), Tokyo, Asian Productivity Organization, 1971, xiv + 748 pp. Price unknown. Paper.

Finney, D. J., *An Introduction To Statistical Science In Agriculture,* New York, John Wiley & Sons, 1972, 290 pp. $17.95.

Fisher, Franklin M., and Karl Shell, *The Economic Theory of Price Indices,* New York, Academic Press Inc., 1972, xv + 117 pp. $6.95.

Frankel, Francine R., *India's Green Revolution: Economic Gains and Political Costs,* Princeton, Princeton University Press, 1971, x + 232 pp. $7.50.

Freeman, III, A. Myrick, Robert H. Haveman, and Allen V. Kneese, *The Economics of Environmental Policy,* New York, John Wiley & Sons, Inc., 1973, xii + 184 pp. $6.95.

Granick, David, *Managerial Comparisons of Four Developed Countries: France, Britain, United States, and Russia,* Cambridge, The MIT Press, 1972, x + 394 pp. $15.00.

Griffin, Roger C., and Stanley Sacharow, *Principles of Package Development,* Westport, The AVI Publishing Company, Inc., 1972, ix + 327 pp. $17.00.

Grossman, Michael, *The Demand for Health: A Theoretical and Empirical Investigation,* New York, National Bureau of Economic Research, 1972, xvii + 115 pp. $3.50. Paper.

Guither, Harold D., *Heritage of Plenty: A Guide to the Economic History and Development of U.S. Agriculture,* 2nd ed., Danville, The Interstate Printers & Publishers, Inc., 1972, xvii + 295 pp. $4.95. Paper.

Guthrie, Rufus K., *Food Sanitation,* Westport, The AVI Publishing Company, Inc., 1972, x + 247 pp. $15.00.

Haveman, Robert H., *The Economic Performance of Public Investments: An Ex Post Evaluation of Water Resources Investments,* Baltimore, The Johns Hopkins Press for Resources for the Future, Inc., 1972, xiv + 126 pp. $7.00.

Inglett, G. E., ed., *Symposium: Seed Proteins,* Westport, The AVI Publishing Company, Inc., 1972, x + 320 pp. $18.00.

Jones, William O., *Marketing Staple Food Crops in Tropical Africa,* Ithaca, Cornell University Press, 1972, xiii + 293 pp. $12.50.

Krutilla, John V., ed., *Natural Environments: Studies in Theoretical and Applied Analysis,* Baltimore, The Johns Hopkins University Press for Resources for the Future, Inc., 1972, viii + 352 pp. $16.50.

Masefield, G. B., *A History of the Colonial Agricultural Service,* New York, Oxford University Press, 1972, iv + 183 pp. $12.75.

McGee, John S., *In Defense of Industrial Concentration,* New York, Praeger Publishers, Inc., 1971, xi + 167 pp. $10.00.

Michael, Robert T., *The Effect of Education on Efficiency in Consumption,* New York, National Bureau of Economic Research, Inc., 1972, x + 139 pp. $3.00. Paper.

O'Neill, Helen B., *Spatial Planning in the Small Economy: A Case Study of Ireland,* New York, Praeger Publishers, Inc., 1971, xv + 221 pp. $15.00.

Rajagopalan, C., and Jaspal Singh, *Adoption of*

Agricultural Innovation: A Sociological Study of Indo-German Project Mandi, Delhi, National Publishing House, 1971, x + 120 pp. Rs. 16.00.

Ramaswami, V. K., *Trade and Development: Essays in Economics,* Cambridge, The M.I.T. Press, 1971, 178 pp. $10.50.

Ronfeldt, David, *Atencingo: The Politics of Agrarian Struggle in a Mexican Ejido,* Stanford, Stanford University Press, ix + 283 pp. $10.00.

Sachchidananda, *Social Dimensions of Agricultural Development,* Delhi, National Publishing House, 1972, x + 197 pp. Rs. 30.00.

Sen, S. R., *Growth and Instability in Indian Agriculture,* Calcutta, Firma K. L. Mukhopadhyay, 1971, viii + 121 pp. Rs. 15.00.

Siegel, Philip H., *Notes and Problems in National Income Analysis,* New York, MSS Information Corporation, 1972, 42 pp. $3.00. Paper.

Southworth, Herman, ed., *Farm Mechanization in East Asia,* New York, The Agricultural Development Council, Inc., 1972, xi + 433 pp. Price unknown. Paper.

Thomas, W. J., ed., *The Demand for Food: An Exercise in Household Budget Analysis,* Manchester, Manchester University Press, 1972, xiii + 136 pp. £3.24.

Thorner, Marvin Edward, *Convenience and Fast Food Handbook,* Westport, The AVI Publishing Company, Inc., 1973, ix + 358 pp. $20.00.

Tomek, William G., and Kenneth L. Robinson, *Agricultural Product Prices,* New York, Cornell University Press, 1972, xiii + 376 pp. $14.50.

Udell, Jon G., *Successful Marketing Strategies in American Industry,* Madison, Mimir Publishers, Inc., 1972, xii + 158 pp. $9.50.

Uphoff, Norman T., and Warren F. Ilchman, eds., *The Political Economy of Development: Theoretical and Empirical Contributions,* Berkeley, University of California Press, 1972, xi + 506 pp. $15.00.

Zarembka, Paul, *Toward a Theory of Economic Development,* San Francisco, Holden-Day, Inc., 1972, xii + 249 pp. $11.95.

Announcements

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joint with
CANADIAN AGRICULTURAL ECONOMICS SOCIETY
WESTERN AGRICULTURAL ECONOMICS ASSOCIATION
University of Alberta
Edmonton, Alberta
August 8–11, 1973

Format of the 1973 Annual Meeting

THURSDAY MORNING, AUGUST 9

AAEA Presidential Address: "Rural and Community Development," Kenneth R. Tefertiller, University of Florida

Invited Address: "Conflicts, Consistencies, and Inconsistencies of the Agricultural Policies of the North American Nations," George Brandow, The Pennsylvania State University

A Canadian Response: J. C. Gilson, University of Manitoba

THURSDAY AFTERNOON, AUGUST 9

Sectional Meeting 1: Firm and Farm Management Literature: A Historical Perspective

Chairman: Lee Martin, University of Minnesota

Paper: "Firm Efficiency Analysis," Ben French, University of California (Davis)

Paper: "Farm Management," Harold Jensen, University of Minnesota

Sectional Meeting 2: Grain Marketing Methods in the United States and Canada

Chairman: T. K. Warley, University of Guelph

Paper: "Grain Marketing Methods in Canada—The Theory, Assumptions and Approach," M. W. Menzies, Winnipeg, Manitoba

Paper: "Grain Marketing Methods in the U.S.A.—The Theory, Assumptions and Approach," Leonard W. Schruben, Kansas State University

Sectional Meeting 3: Grain Handling and Transportation

Chairman: Roy E. Huffman, Montana State University

Paper: "A Rationalization Model for the Canadian Grain Handling and Transportation Systems," E. W. Tyrchniewicz and R. J. Tosterud, University of Manitoba

Paper: "Grain Movement—Barge and Rail Competition," O. Sorenson, Kansas State University

Sectional Meeting 4: The Farm Machinery Industry in Canada and the United States

Chairman: George Irwin, USDA-ERS, North Carolina State University

Paper: "The Report of the Canadian Commission," Clarence Barber, University of Manitoba

Seminar 1: Public and Private Sector Issues for Sparsely Settled Communities and Regions

Chairman: B. Delworth Gardner, Utah State University

Session 1.1: "Economics of Sparsely Settled Communities"

Session 2.1: "The Pricing and Allocation of Publicly Owned Resources"

Seminar 2: Structural Control of Agriculture and the Food System

Chairman: Kenneth R. Krause, USDA-ERS, Washington, D.C.

Session 2.1: "Who Will Control Agriculture: Implications of Structural Change"

Session 2.2: "The Problems of Value Determination of Agricultural Commodities"

Session 2.3: "Structural Effects of Federal Income Taxes"

THURSDAY EVENING, AUGUST 9

Fellows Address
Paper: D. Gale Johnson, University of Chicago
Awards Program
Chairman: Bernard F. Stanton, Cornell University

FRIDAY MORNING, AUGUST 10

General Session
Invited Address: "Natural Resources and Environmental Quality," Robert Haveman, University of Wisconsin
Invited Address: "Manpower Potential—North American Continent," David Hopper, International Development Research Agency, Ottawa, Ontario
CAES Presidential Address: Gerald I. Trant, Canada Department of Agriculture

FRIDAY AFTERNOON, AUGUST 10

AAEA Business Meeting
Sectional Meeting 5: Agricultural Adjustment-Selected Programs and Approaches
Chairman: Walton J. Anderson, Canada Department of Agriculture, Ottawa, Ontario
Paper: "The Cotton Industry in the Southwest USA," Robert Firch, University of Arizona
Paper: "Agricultural Development Policies and Programs in Canada," D. H. Plaunt, Canada Department of Agriculture, Ottawa, Ontario
Paper: "Farm Labor and Agricultural Income," Brian Perkins, Canada Department of Agriculture, Ottawa, Ontario
Sectional Meeting 6: Managerial Information Data Systems
Chairman: Charles Beer, USDA-FES, Washington, D.C.
Paper: "Managerial Information Data Systems in Canada," R. C. Nicholson and G. E. Lee, University of Saskatchewan
Paper: "Managerial Information Data Systems in the U.S.," Ludwig Eisgruber, Purdue University
Sectional Meeting 7: Minority Problems and Agriculture
Chairpersons: Percy R. Luney and Anne E. Hammill, Office of Equal Opportunity, USDA, Washington, D.C.
Paper: "Migration Patterns of Minorities in the U.S.," Calvin Beale, USDA-ERS, Washington, D.C.
Paper: "The Role of the 1890 Colleges and Universities in Research on Minorities Problems," T. T. Williams, Southern University, Baton Rouge, Louisiana
Paper: "Traditional Graduate Admission Standards as Constraints to Increasing the Supply of Black Professional Agriculturalists: The Florida Experience," Carlton G. Davis, University of Florida
Seminar Session 3: Forest Economics
Chairman: Richard McConnen, Montana State University
Seminar Session 4: Agricultural Extension: The U.S. and Canadian Experience Compared
Chairpersons: Henry Wadsworth, Purdue University, and Brock Whale, University of Saskatchewan

FRIDAY EVENING, AUGUST 10

Industry and International Dinner
Speaker: Ambassador William Pearce
University Reunion Parties

SATURDAY MORNING, AUGUST 11

Sectional Meeting 8: Public Sector Research and Education and the Agri-Business Complex: Unholy Alliance or Socially Beneficial Partnership?
Chairman: Dale Hathaway, Ford Foundation and Michigan State University
Paper: Harold Breimyer, University of Missouri
Paper: Alex F. McCalla, University of California (Davis)
Paper: An Industry Economist
Panel Discussion
Sectional Meeting 9: Water Resource Development and the North American Continent
Chairman: E. Roy Tinney, Canada Department of Energy, Ottawa, Ontario
Special Feature: A discussion session, date and time to be announced, chaired by James D. Shaffer, Michigan State University

CONTRIBUTED PAPERS SESSIONS OF THE AAEA ANNUAL MEETING

Contributed papers sessions will be scheduled in the following topic areas:

1. Farm and Firm Management
2. Marketing and Price Analysis (Both Inputs and Commodities)
3. Rural and Community Development
4. Natural Resource Economics
5. Economic Policy Including Agricultural Policy and International Trade
6. Methodology
7. General Agricultural Economics
8. Extension Education
9. Ethnic Problems in U. S. and Canadian Agriculture

Authors of contributed papers should submit the proposed titles to the Chairmen of the contributed papers sessions by May 1. Finished manuscripts must be in the hands of the Chairmen by June 15. Each author should indicate the topic area in which he would like to present his paper. Because of scheduling problems, no individual will be scheduled to present more than one contributed paper at the meetings.

Co-Chairmen of the contributed papers sessions are:

Dr. David H. Boyne

Dr. Francis E. Walker
Department of Agricultural Economics and Rural Sociology
The Ohio State University
2120 Fyffe Road
Columbus, Ohio 43210

Papers presented in the contributed papers sessions will be reported by title and author in the Proceedings Issue of the *AJAE*. Authors of contributed papers are invited to submit their manuscripts to the Editor of the *AJAE* to be considered for publication. Such manuscripts will be subject to the normal review process.

1973
NOMINEES FOR OFFICES OF THE AAEA

PRESIDENT

James Nielson, Washington State University
Luther Tweeten, Oklahoma State University

DIRECTORS

I

B. Delworth Gardner, Utah State University
and
Howard F. Robinson, North Carolina Agricultural and Technical State University

II

Charles E. Erickson, Cargill, Inc., Minneapolis
and
Glenn E. Heitz, Federal Land Bank of St. Louis

WESTERN RESOURCES CONFERENCE

The 15th Annual Western Resources Conference, with the theme "Salinity: A Critical Review of Causes and Control," will be held at the University of Colorado, Boulder, July 9–11, 1973. The Conference, through expert speakers and workshop groups, will assess the state of the art of diagnosing causes and designing efficient controls over growing salinity in water supplies. National and international problems will be addressed.

Further announcements and program will be forthcoming. For further information, write: Bureau of Conferences and Institutes, Division of Continuing Education, University of Colorado, Boulder, Colorado 80302.

ENERGY, GROWTH, AND POLLUTION

On July 16–18, 1973, a Sem–Shop on Energy, Growth, and Pollution will be sponsored by the Departments of Geology and Economics, Ohio University. For details contact R. K. Koshal, 315 Copeland Hall, or Workshop Office, 301 Tupper Hall, Ohio University, Athens, Ohio 45701.

AGRICULTURAL PRODUCTIVITY IN ASIA

Twenty-one agricultural economists and other specialists participated in a February 6–9, 1973, conference at the East–West Center, Honolulu, Hawaii, on "Measuring the Growth in Agricultural Productivity in Asia." The conference was sponsored by the East–West Food Institute, the Economic Development Center of the University of Minnesota in St. Paul, the Agricultural Development Council, and the Asian Productivity Organization, and was coordinated by Drs. Nicolaas Luykx and Vernon Ruttan.

FORD FOUNDATION GRANTS AWARDED

The Ford Foundation has awarded grants to 13 universities in the United States and Canada through a competition to encourage research on problems common to advanced industrial societies. Six grants were made at or near the maximum award of $150,000 to Massachusetts Institute of Technology, Emory University, Princeton University, Rutgers University, Carnegie-Mellon University, and the University of California (Los Angeles). Seven grants of $50,000 each were made to the University of Florida, University of Mississippi, City University of New York, University of Illinois, Northwestern University, Ohio State University, and the University of Montreal.

FAR WESTERN AGRICULTURAL HISTORY

"Agriculture in the Development of the Far West" is the theme for a three-day symposium to be held on the Davis campus of the University of California, June 1974. The University, USDA, and the Agricultural History Society among others are sponsoring the meeting and a program of papers which will be printed in a special issue of ***Agricultural History***. The intention is to present a scholarly and interdisciplinary program including papers that show how agriculture has been involved in western development (land, water, technoloy, labor, marketing, policies, resources for historical study, etc.). To ask information or offer suggestions, contact the Agricultural History Center, University of California, Davis, California 95616.

NEW PH.D. PROGRAM

The School of Agricultural Economics of the University of Guelph has been authorized to offer a PH.D. degree program in agricultural economics. The program has been in effect since July 1, 1972.

AAEA COMMITTEE STRUCTURE, 1972–1973

AWARDS COMMITTEE

B. F. Stanton, Chairman, New York, 1972

Distinguished Undergraduate Teacher Award

John Goodwin, Chairman, Oklahoma State, 1971
David Armstrong, Michigan State, 1970
Robert L. Christensen, Massachusetts, 1970
David Downey, Purdue, 1972 (student)
Thomas L. Frey, Nebraska, 1971
Russell McDonald, California Polytechnic, 1972 (student)
Eddie Miller, Oklahoma State, 1972 (student)
Jack C. Thompson, Georgia, 1970

Distinguished Extension Program and Publications Awards

Jean B. Wyckoff, Chairman, Oregon State, 1970
John S. Bottum, ERS, USDA, 1970
William M. Carroll, Pennsylvania State, 1971
Martin K. Christianson, Minnesota, 1971
Duane E. Erickson, Illinois, 1971
Roger Johnson, North Dakota State, 1972
Henry Meenan, Arkansas, 1970
Gordon Rose, South Dakota State, 1972

Published Research Awards

J. A. Seagraves, Chairman, North Carolina State, 1970
W. R. Butcher, Washington State, 1970
Dale E. Butz, FS Services, 1971
George Capel, North Carolina State, 1972
Ralph Kline, Virginia Polytechnic, 1972
B. V. Lessley, Maryland, 1970
Donald S. Moore, Texas A & M, 1971
W. C. Motes, EDD, ERS, USDA, 1970
Brian B. Perkins, Canada Dept. of Agriculture, 1971
Schlomo Reutlinger, Washington, D.C., 1971
Gene Swackhammer, FCA, 1971
R. G. Walsh, Colorado State, 1972
John Wildermuth, Arizona, 1972

Master's Thesis Awards

Robert W. Herdt, Chairman, Illinois, 1970
David J. Allee, Cornell, 1970
B. W. Bobst, Kentucky, 1972
Ray Brokken, Oregon State, 1972
Johannes Delphendahl, Maine, 1972
James R. Gray, New Mexico State, 1971
H. C. Lampe, Rhode Island, 1972
Tsoung-Chou Lee, Connecticut, 1971
Steve Lytle, Clemson, 1971
Doug Morris, New Hampshire, 1972
Wallace Rehberg, Washington State, 1970
Edward H. Ward, Montana State, 1971
T. T. Williams, Southern University, Louisiana, 1970

Doctoral Dissertation Awards

Joseph C. Purcell, Chairman, Georgia, 1969
Dan W. Bromley, Wisconsin, 1970
Rachel Dardis, Maryland, 1972
Kenneth D. Duft, Washington State, 1972
Bernard Erven, Ohio State, 1972
Donald E. Farris, Texas A & M, 1970
Marvin Hayenga, Michigan State, 1971
Gordon King, California-Davis, 1972
George M. Ladd, Iowa State, 1971
Frank Orazem, Kansas State, 1970
Gary Seevers, Washington, D.C., 1972
Fred H. Tyner, Mississippi State, 1970

PROFESSIONAL ACTIVITIES

Luther T. Wallace, Chairman, California, 1971
Charles Erickson, Cargill, Inc., 1968
Raymond O. P. Farrish, Connecticut, 1970
R. J. Hildreth, Farm Foundation, 1971
Linley E. Juers, ERS, USDA, 1971
Lester V. Manderschied, Michigan, 1969
James S. Plaxico, Oklahoma State, 1970
Lyle P. Schertz, ERS, USDA, 1970
Henry A. Wadsworth, Purdue, 1970

EDUCATIONAL

Lester V. Manderschied, Chairman, Michigan State, 1972
Timothy M. Hammonds, Oregon State, 1972
John Helmberger, Minnesota, 1969
Paul Kelley, Kansas State, 1972
John G. McNeely, Jr., Texas A & M, 1970
Fred A. Mangum, North Carolina State, 1969
Eldon E. Weeks, ERS, USDA, 1971

EXTENSION AFFAIRS

Henry A. Wadsworth, Chairman, Purdue, 1970
John S. Bottum, ERS, USDA, 1971
William Carroll, Pennsylvania State, 1972
George Casler, Cornell, 1972
Kenneth D. Duft, Washington State, 1971
W. Neill Schaller, Farm Foundation, 1970

INDUSTRY ADVISORY

Charles E. Erickson, Chairman, Cargill, Inc., 1968
Paul Baumgart, Safeway Stores, Inc., 1970
W. E. Christian, Uncle Ben's Inc., 1971
Glenn E. Heitz, The Federal Land Bank of St. Louis, 1970
Gerald G. Quackenbush, American Dairy Association, 1970
Vernon Schneider, Am. Inst. of Cooperation, 1970
Claud L. Scroggs, Southern States Cooperative, Inc., 1970
Raymond E. Seltzer, Dunlap and Associates, 1970
Ronald Warfield, Central Soya, Inc., 1972

INTERNATIONAL

Lyle P. Schertz, Chairman, ERS, USDA, 1970
Norman Collins, Ford Foundation, 1972
Louis M. Goreux, Washington, D.C., 1971
Clive Harston, Texas A & M, 1972
Earl O. Heady, Iowa State, 1970
Nicolaas Luykx, East-West Center, 1970
Max Myers, South Dakota State, 1970
Wyn F. Owen, Colorado, 1968
O. J. Scoville, Kansas State, 1972
Eldon D. Smith, Kentucky, 1969
Anthony M. Tang, Vanderbilt, 1970

AUDIT

James E. Criswell, Chairman, Kentucky, 1970
Fred E. Justus, Jr., Kentucky, 1970

BIBLIOGRAPHICAL

Lee M. Day, Chairman, Pennsylvania State, 1969
Fred H. Abel, ERS, USDA, 1969
W. Darcovich, Canada Dept. of Agriculture, 1970
J. Edwin Faris, Washington State, 1970
Ivan Schmedemann, Texas A & M, 1972
John T. Scott, Illinois, 1972

DIRECTORY

Robert W. Rudd, Chairman, Kentucky, 1969
Clifton B. Cox, Armour & Co., 1969
John C. Redman, Kentucky, 1969
Wesley B. Sundquist, Minnesota, 1969

ECONOMIC STATISTICS

James T. Bonnen, Chairman, Michigan State, 1969
R. James Hildreth, Farm Foundation, 1969
George G. Judge, Illinois, 1969
George S. Tolley, University of Chicago, 1969
Harry C. Trelogan, SRS, USDA, 1970
Quentin M. West, ERS, USDA, 1972

EMPLOYMENT SERVICES

Loys L. Mather, Chairman, Kentucky, 1968
David H. Boyne, Ohio State, 1969
Carleton Dennis, Agway, Inc., 1972
Dale E. Hathaway, Michigan State, 1971
Melvin R. Janssen, EDD, ERS, USDA, 1969
Howard Robinson, North Carolina State, 1972

FELLOWS ELECTION

Maurice M. Kelso, Chairman, Tucson, Arizona, 1968
Karl Fox, California, 1972
Glenn L. Johnson, Michigan State, 1970
Nathan M. Koffsky, Chevy Chase, Maryland 1969
Don Paarlberg, USDA, 1971

INSTITUTIONAL MEMBERSHIP

Sherwood O. Berg, Chairman, Minnesota, 1971
S. Kent Christensen, National Assn. of Food Chains, 1965
Joseph H. Marshall, Cotton Producers Association, 1970
Charles R. Sayre, Staple Cotton Cooperative Association, 1965
Raymond E. Seltzer, Dunlap & Associates, 1970
Lauren K. Soth, Des Moines Register and Tribune, 1965
Roy G. Stout, Coca-Cola, Atlanta, Georgia, 1970

INVESTMENT

John C. Redman, Chairman, Kentucky, 1969
Dale E. Butz, FS Services, 1970
C. D. Kearl, Cornell, 1958

MEMBERSHIP

John Lee, Chairman, ERS, USDA, 1972
John Redman, Kentucky, 1970

NOMINATING

Vernon W. Ruttan, Chairman, Minnesota, 1972
John O. Gerald, MED, ERS, USDA, 1972
William Lanham, Clemson, 1972
Martin T. Redfern, Arkansas, 1972
O. J. Scoville, Kansas State, 1972
Wesley Seitz, Illinois, 1972
Frederick J. Smith, Oregon State, 1972
Gene L. Swackhammer, FCA, 1972

POSTWAR LITERATURE REVIEW

Lee R. Martin, Chairman, Minnesota, 1967
John P. Doll, Missouri-Columbia, 1968
Peter G. Helmberger, Wisconsin, 1969
Glenn L. Johnson, Michigan State, 1967
Maurice M. Kelso, Tucson, Arizona, 1967
J. Patrick Madden, Pennsylvania State, 1969
Edward W. Tyrchniewicz, Manitoba, 1969
Melvin L. Upchurch, Florida, 1967

STUDENT AFFAIRS

Donald J. Epp, Chairman, Pennsylvania State, 1970
Daniel D. Badger, Oklahoma State, 1970
Sydney James, Iowa State, 1972
John W. Nixon, Georgia, 1971
Frank H. Osterhoudt, New Mexico State, 1971
Joseph Richter, Alberta, 1972 (Host School Liaison)
Edward W. Tyrchniewicz, Manitoba, 1971
Kenneth E. Wing, Maine, 1972

AAEA BOARD MEMBER LIAISON

W. B. Sundquist, Minnesota, 1972

TELLERS

Bruce R. Beattie, Chairman, Kentucky, 1970
A. Frank Bordeau, Jr., Kentucky, 1970

VISITING PROFESSOR

R. J. Hildreth, Chairman, Farm Foundation, 1969
Emiel W. Owens, Houston, 1969
John E. Thompson, South Dakota State, 1969
Andrew Vanvig, Wyoming, 1969

AAEA Representative to the Agricultural Development Council, Research and Training Network Program (ADC/RTN)

Lyle Schertz, ERS, USDA

AAEA Representative to the American Society of Agronomy

(Mutual appointment with the American Society of Agronomy)
C. R. Hoglund, Michigan State

AAEA Representative to Council for Agricultural Science and Technology

George E. Brandow, Pennsylvania State

AAEA Representative to the National Bureau of Economic Research

Harold G. Halcrow, Illinois

AAEA Representative to the National Research Council

George E. Brandow, Pennsylvania State

AAEA Representative to the Bureau of Census Advisory Committee on Agricultural Statistics

James T. Bonnen, Michigan State

ASA-AAEA Joint Advisory Committee on Agricultural Statistics

James T. Bonnen, Chairman, Michigan State
George C. Judge, Illinois
Dean McKee, Deere & Co.

U. S. Council of the International Association of Agricultural Economics

Vernon W. Ruttan, Chairman, Minnesota
Harold F. Breimeyer, Missouri
Max Myers, South Dakota State
Melvin L. Upchurch, Florida

AAEA Representative to Allied Social Science Associations Winter Meetings

S. H. Lane, Guelph

AJAE Evaluation

Stephen Smith, Chairman, Wisconsin
Gordon A. King, California-Davis
William Motes, EDD, ERS, USDA
Claud Scroggs, Southern States Cooperative
Stanley Seaver, Connecticut
Herbert Stoevener, Oregon State
Earl Swanson, Illinois
George Tolley, University of Chicago
H. A. Wadsworth, Purdue

AAEA Student Affairs Evaluation

James S. Plaxico, Chairman, Oklahoma State
Emerson M. Babb, Purdue
Donald J. Epp, Pennsylvania State
James G. Kendrick, Nebraska
Lester V. Manderschied, Michigan State
John Sjo, Kansas State
Walter J. Wills, Southern Illinois

CALCUTTA

News Notes

UNIVERSITY OF ARKANSAS

Reassignments: **Harold M. Bone** has completed his M.S. degree and is working for the Federal Land Bank in Wichita, Kansas; **Tommy Couch** has completed his M.S. degree and will be a grain merchandiser with Central Soya, Inc., Decatur, Indiana.

UNIVERSITY OF CALIFORNIA, DAVIS

Leave: **Hoy F. Carman**, sabbatic leave until November 30, 1973, to undertake research on problems of marketing New Zealand meat products, with emphasis on export market, at Palmerston, North, New Zealand.

THE UNIVERSITY OF CHICAGO

Honor: On December 29, 1972 **Theodore W. Schultz** became the 6th recipient of the Francis A. Walker Medal of the American Economics Association. The Medal is awarded every five years to an economist making outstanding contributions in his field. Schultz is in charge of two major studies, to appear in the *Journal of Political Economy,* sponsored and financed by the National Bureau of Economic Research and the Population Council.

CLEMSON UNIVERSITY

Appointments: **Kenneth J. Roberts**, Ph.D. Oregon State, assistant professor; C. Stassen Thompson, Ph.D. University of Kentucky, assistant professor.

COLORADO STATE UNIVERSITY

Appointment: **Phillip Knox**, assistant professor.

CORNELL UNIVERSITY

Appointment: **Dennis R. Lifferth**, Ph.D. Iowa State, assistant professor.

ECONOMIC RESEARCH SERVICE, USDA

(EDD, Economic Development Division; ESAD, Economic and Statistical Analysis Division; FDCD, Foreign Demand and Competition Division; FDD, Foreign Development Division; FPED, Farm Production and Economics Division; MED, Marketing Economics Division; NRED, Natural Resource Economics Division.)

Appointments: **Clifford Carmen**, ESAD; **Max Jordan**, EDD, appointed Chief of Human Resources Branch, EDD; **Frederick Linse**, ESAD; **Myles Mielke**, FDCD; **Gerald Plato**, ESAD; **Gerald Rector**, ESAD; **Henry C. Trainor**, FDCD; **Randolph Zeitner**, ESAD.

Reassignments: **Rodney C. Kite**, MED-Lafayette, Indiana, to ESAD-Washington, D.C.; **Charles E. Overton**, MED-Lafayette, Indiana, to MED-Washington, D.C.; **Leon B. Perkinson**, EDD-East Lansing, Michigan, to EDD-Raleigh, North Carolina; **Daniel Piper**, NRED-East Lansing, Michigan, to NRED-Lincoln, Nebraska; **James G. Vertrees**, MED, to Office of the Secretary.

Resignations: **Peter Ashton**, NRED-Berkeley, California, to Forest Service, Washington, D.C.; **Ronald Drake**, NRED-Washington, D.C., to Department of Commerce; **Meyer Harron**, ESAD-Washington, D.C., to Treasury Department.

ECONOMICS BRANCH, AGRICULTURE CANADA

Appointments: **Thomas Bennett**, marketing and trade division; **Walter T. Burns**, named Associate Director, Farm Management Division; **Sean Bun Chin**, assistant research economist; **C. T. (Chuck) Craddock**, research economist; **Arnold J. de Leeuw**, trade policy economist; **Zuhair A. Hassan**, working in demand analysis and consumer economics; **D. H. Hedley**, branch commodity manager for oilseeds; **Glen Hildreth**, International Liaison Service; **H. B. (Bruce) Huff**, branch commodity manager for beef; **T. C. Kerr**, feed grains and branch programs; **Brian B. Perkins**, policy advisor; **Wendy Smith**, assistant research economist; **Dennis Ware**, Economics Branch representative to the Research Branch's Planning and Co-ordination Group, co-ordinator for professional recruitment, and associate director of Research Division.

UNIVERSITY OF FLORIDA

Appointments: **Donald L. Brooke**, professor, as acting head of the Department of Food and Resource Economics, replacing **Kenneth R. Tefertiller**, professor, appointed Vice President for Agricultural Affairs, Institute of Food and Agricultural Sciences; **Wen-Shyong Chern,** Ph.D. California-Berkeley, assistant professor; **James A. Niles,** Ph.D. California-Davis, assistant professor.

Reassignment: **W. K. Boutwell,** Florida Board of Regents, to Vice Chancellor of Florida State University System.

Resignation: **J. Richard Conner,** assistant professor, to the Florida Board of Regents, Division of Planning and Analysis.

Retirement: **Daniel E. Alleger,** associate professor, after 27 years of service.

UNIVERSITY OF GUELPH

Appointments: **Tim Josling,** visiting professor on leave from the London School of Economics; **Wen-Fong Lu,** Ph.D. Manitoba, post-doctoral fellow; **Roger Mauldon,** on leave from the University of Western Australia, as consultant to Canfarm and associated graduate faculty member; **Jay Strom,** Ph.D. Purdue, has joined Canfarm Farm Management Systems as liaison between Can-Farm and the School of Agricultural Economics and Extension Education; **Neil Sturgess,** on leave from the University of Melbourne, visiting professor.

Leave: **Murray A. MacGregor,** professor, to the University of Edinburgh for one year.

Resignation: **Robert Batterham,** assistant professor, to the University of Sydney.

Return: **Jack H. Clark,** associate professor, from two year leave of absence in Malaysia as agricultural economist with the Canadian International Development Agency, Pahang Tenggara Regional Master-planning Study.

UNIVERSITY OF HAWAII AT MANOA

Award: **Chennat Gopalakrishnan,** associate professor, to begin a Senior Fellowship at the East-West Food Institute July 1 to study the legal, economic, and institutional aspects of fisheries and marine resources management.

UNIVERSITY OF ILLINOIS

Appointment: **David A. Lins,** assistant professor.

IOWA STATE UNIVERSITY

Resignations: **A. Gordon Ball,** professor of economics and associate director of the Center for Agricultural and Rural Development, to become associate dean of the College of Agriculture, University of Guelph; **Stephen E. McGaughey,** assistant professor on the Iowa-Peru project, to accept a position with the International Development Bank.

UNIVERSITY OF MANITOBA

Appointments: **Charles F. Framingham,** formerly of the Planning and Priorities Committee of Cabinet, Manitoba, as associate professor; **Daryl F. Kraft,** Ph.D. candidate Michigan State, assistant professor.

Leaves: **Om P. Tangri,** sabbatical leave 1972–73 academic year and January-June 1973 appointment as Honorary Research Fellow in Economics, Harvard University; **Martin H. Yeh,** to Santiago, Chile with the United Nations Economic Commission for Latin America for two years.

UNIVERSITY OF MINNESOTA

Resignation: **Osama A. Al-Zand,** to the Canada Department of Agriculture, Ottawa.

UNIVERSITY OF MISSOURI

Leave: **Joseph C. Headley,** sabbatical leave: Sept. 1–Dec. 1, guest professor at The Agricultural College of Norway, Vollebekk; Dec. 1–April 1, visiting professor at the Institute for Economics and Statistics at Upsala, Sweden; April 1–Aug. 1, visiting professor at the Agricultural College of Denmark.

Reassignment: **Robert E. Zellner,** Ph.D. University of Missouri, from Post Doctoral Fellowship, University of Guelph, to Economic Analyst, Canadian Bell Telephone Company, Montreal.

OKLAHOMA STATE UNIVERSITY

Appointments: **Mike L. Hardin,** Extension Farm Management Associate; **Stephen A. Onii,** visitiing professor from University of Ibadan, Ibadan, Nigeria, one year.

Resignation: **Alan R. Tubbs,** to First Central Bank, DeWitt, Iowa.

OREGON STATE UNIVERSITY

Appointment: **James B. Fitch,** A.A. Stanford University, assistant professor; **Harvey A. Meier,** Ph.D. Ohio State, assistant professor and Extension marketing/management specialist.

Reassignment: **Joe B. Stevens** has accepted half-time appointment to the staff of the Western Region Area Development Research Center and continues as associate professor in the Department of Agricultural Economics for the balance of his time.

PURDUE UNIVERSITY

Appointments: **Otto C. Doering III,** assistant professor; **Bruce A. McCarl,** assistant professor; **Frederick W. Obermiller,** assistant professor.

Resignation: **William G. Bursch,** to Experience, Incorporated, as staff economist, Minneapolis, Minnesota.

STANFORD UNIVERSITY

Appointments: **W. Whitney Hicks,** as visiting associate professor from University of Missouri-Columbia, academic year 1972–73; **Wuu-Long Lin,** Ph.D. candidate Stanford, as research associate.

UNIVERSITY OF TENNESSEE

APPOINTMENT: **Larry C. Morgan**, assistant professor.

LEAVE: **James G. Snell**, to Center for Agricultural Marketing Development, FAO, Tehran, Iran, for one year.

WASHINGTON STATE UNIVERSITY

LEAVE: **Walter R. Butcher**, to University of Wisconsin as visiting professor, January through May 1973.

UNIVERSITY OF WISCONSIN-MADISON

APPOINTMENTS: **Richard L. Barrows**, Ph.D. University of Wisconsin, assistant professor; **Melville L. McMillan**, assistant professor; **Hans P. Peterson**, Ph.D. University of Wisconsin, Project Associate.

REASSIGNMENTS: **Marvin P. Miracle** will be in the Central Province of Kenya conducting research on innovations in agriculture under a Ford Foundation grant until June 1974; **Hugh L. Cook** will head the Department of Agricultural Economics, University of Ife, Western State, Nigeria, for two-three years under a Wisconsin/USAID contract.

THE UNIVERSITY OF WYOMING

RESIGNATION: **Rollo L. Ehrich**, professor and agricultural economist, to USAID/Lima, Peru.

OTHER APPOINTMENTS:

Howard B. Anderson, M.S. Purdue, grain merchandiser, Tabor & Co., Peoria, Illinois.

Edgardo Barandiaran, Ph.D. Minnesota, Facultad de Economia, Universidad Catolica de Chile, Santiago, Chile.

Aldo Louis Biondolillo, Ph.D. Minnesota, professor, Facultad de Ciencias Economicas, Universidad de Cuyo, Mendoza, Argentina.

Calvin L. Brints, Ph.D. Minnesota, area economist, Agricultural Extension Service, Texas A & M, El Paso.

A. John DeBoer, Ph.D. Minnesota, Faculty of Agriculture, University of Queensland, Australia.

James J. Fritz, M.S. Purdue, supply officer, USAF.

G. William Goldiniger, Jr., M.S. Missouri, partnership manager in 1000 acre grain, hog, cattle farm, Hannibal, Missouri.

Parman R. Green, M.S. Missouri, fieldman, Federal Land Bank, Omaha, Nebraska.

Gary Edwin Gries, M.S. Missouri, market analyst, Agricultural Chemicals Division, ICI America, Wilmington, Delaware.

Jerry Joe Kropf, Ph.D. Missouri, Extension livestock marketing, Montana State University.

Paul F. Langewisch, M.S. Missouri, fieldman, Federal Land Bank, St. Louis, Missouri.

Chang I. Lin, M.S. Purdue, Instructor, National Taiwan University, Taiwan.

James C. Lowe, Ph.D. Wisconsin, to the Economic Branch, Canada Department of Agriculture, Regina, Saskatchewan.

Karl D. Meilke, Ph.D. Minnesota, assistant professor, University of Guelph.

Jeffrey L. Miller, M.S. Purdue, dairy research and analysis coordinator, Purdue University.

Mohammed Sulieman, Ph.D. Missouri, associate professor, University of Arkansas-Pine Bluff.

William W. Wade, Ph.D. Minnesota, economic analyst, Standard Oil Company of California, San Francisco.

OBITUARIES

Albert O. "Bob" Follett, 78, emeritus assistant professor, University of Wisconsin, died November 10, 1972.

Follett was a faculty member of the Department of Agricultural Economics at Wisconsin from December 1935 to his retirement in December 1959. Recognized as a pioneer in the development of farm managed associations throughout Wisconsin, he served as Extension Economist in Farm Management. Upon graduation from the University of Wisconsin in 1928, he spent two years as fieldman for a detailed cost accounting route and five years as a county agricultural agent in northern Wisconsin. Follett received the Purple Heart in France during World War I.

Willie Solomon Hutson, 52, economist in the U. S. Department of Labor, died of cancer on January 4, 1973 in Knoxville, Tennessee.

He had been ill for more than a year but continued working until three months before his death. Hutson was born in Tennessee and attended Milligan College before receiving his B.S. at the University of Tennessee. He received the M.S. from the University of Kentucky and did additional graduate studies at the Universities of Wisconsin and Minnesota. He served as coordinator of the Northeast Regional Livestock Marketing Research Committee and then as Coordinator of the Southern Regional Poultry Marketing Research Committee. Prior to his Labor Department assignment, he was a statistician in the U. S. Department of Commerce. He was married to the late Viola Willis Hutson and is survived by his son Willis Frank Hutson and one sister. He is remembered by his friends for his good humor and friendly concern.

Elmer L. Sauer, professor emeritus of the University of Illinois, died on August 16, 1972. He was born in Sedalia, Missouri, in April 1910, but spent almost all his life in Illinois.

Sauer earned three degrees at the University of Illinois: B.S. in 1931, M.S. in 1934, and Ph.D. in 1947. Always greatly interested in soil and water conservation, he was a founder of the Soil Conservation Society of America and served that organization in many capacities over the years. He was elected a Fellow of the Society in 1955 and was national president in 1960. From 1936 to 1950, he held a USDA appointment in the Soil Conservation Service and was a recipient of the USDA Award for Superior Service in 1956.

In 1961 Sauer joined the Cooperative Extension Service of the University of Illinois and served as leader of a project on Community and Public Affairs. He was active in rural development work at the national, state, and local levels. In 1967 he was a Fulbright Visiting Professor at the University of the West Indies, Trinidad.

Will M. Simmons, 55, USDA economist, died of a heart attack on November 28, 1972, while visiting relatives in Florida. He had been on sick leave for about six months prior to his death.

Widely known as an authority in commodity analysis, Simmons had 19 years service with USDA. During the past 16 years, he had been with the Economic Research Service, serving successively as Head of the Fruit and Vegetable Section, Chief of the Commodity Analysis Branch, and Deputy Director of the Economic and Statistical Analysis Division.

He was born and received his early education in West Florida, graduating magna cum laude from the University of Florida in 1942. He served four years in the Navy during World War II, then took his M.S. and Ph.D. degrees from Cornell University. Before joining USDA, he worked as assistant professor of agricultural economics at Cornell and as a commodity analyst with a private investment firm.

Simmons is survived by his wife, Mildred Gasque Simmons of Springfield, Virginia, two children, one grandchild, and one sister.

DOCTORAL DEGREES IN AGRICULTURAL ECONOMICS CONFERRED IN 1972, BY SUBJECT AREA

CATEGORIES

I. Agricultural Economics, General
II. Agricultural Finance, Capital, Credit
III. Agricultural Income
IV. Agricultural Labor; Rural Manpower
V. Agricultural Products: Demand, Supply, Prices
VI. Cooperatives and Cooperation
VII. Economic Development, Growth and Planning
VIII. Environmental Economics
IX. Food and Consumer Economics
X. General Economics
XI. Human Resource Development
XII. Industrial Organization
XIII. Marketing and Location
XIV. Natural Resource Economics
XV. Production Economics and Management
XVI. Public Policy Programs
XVII. Regional Economics
XVIII. Research Methodology
XIX. Rural Appraisal and Taxation
XX. Social Welfare and Socioeconomic Change
XXI. Technological Change
XXII. Other (Specify)

I. AGRICULTURAL ECONOMICS, GENERAL

Gustavo Adolfo Nores, Certified Public Accountant, University of Cordoba, 1965; M.S. Purdue University, 1969; Ph.D. Purdue University, *Quarterly Structure of the Argentine Beef Cattle Economy: A Short-Run Model, 1960–1970.*

II. AGRICULTURAL FINANCE, CAPITAL, CREDIT

Marvin R. Fausett, B.S. University of Missouri, 1961; M.S. University of Missouri, 1970; Ph.D. University of Missouri, *An Empirical Study of the Economic Growth and Capital Formation on Selected Missouri Dairy Farms.*

Richard S. Fenwick, Jr., B.S. Colorado State University, 1962; M.S. Colorado State University, 1965; Ph.D. University of Missouri, *Capital Acquisition-Strategy For Missouri Farm Supply Cooperatives.*

James Bruce Hottel, B.S. Oklahoma State University, 1958; M.S. Oklahoma State University, 1960; Ph.D. Texas A&M University, *An Analysis of the Financial Structure and Financial Management Practices of Rice Producers in the Coastal Prairie of Texas.*

David Aloysius Lins, B.S. University of Wisconsin, 1966; M.S. University of Wisconsin, 1968; Ph.D. University of Illinois, *An Analysis of Sources and Uses of Funds in the Farm Sector of the United States.*

Harvey Alexander Meier, B.S. Washington State University, 1966; M.S. University of Arizona, 1968; Ph.D. Ohio State University, *Agricultural Lending Attitudes, Practices and Activities of Ohio Commercial Bankers.*

Charles A. O'Dell, B.S. Texas Technological College, 1960; M.S. Texas Technological College, 1962; Ph.D. University of Maryland, *A Simulation of Long-Run Adjustment Patterns in Capital Formation in the Grain Handling and Storage Industry, 1960–1975.*

P. Lucio Scandizzo, Graduate, University of Naples, 1965; M.S. University of California at Berkeley, 1970; Ph.D. University of California at Berkeley, *International Capital Movement and Economic Growth.*

III. AGRICULTURAL INCOME

Ronald Jay Hanson, B.S. Western Illinois University, 1968; M.S. University of Illinois, 1970; Ph.D. University of Illinois, *An Economic Analysis of Off-Farm Income as a Factor in the Improvement of the Low Farm Income Farmers in Illinois.*

IV. AGRICULTURAL LABOR; RURAL MANPOWER

Eliseu Roberto de Andrade Alves, B.S. UREMG, 1954; M.S. Purdue University, 1968; Ph.D. Purdue University, *An Econometric Study of the Agricultural Labor Market in Brazil: A Test of Subsistence and Commercial Family Farm Models.*

Mark S. Freeland, B.S. Iowa State University, 1966; M.A. University of Wisconsin, 1969; Ph.D. University of Wisconsin, *Determinants of the Incidence of Work Limitations Associated with Chronic Illness and Impairments.*

Richard B. Smith, B.S. University of Missouri, 1964; M.S. Iowa State University, 1969; Ph.D. Iowa State University, *Pay Packages and Employment Conditions of Farm Employees in Eastern Iowa.*

V. AGRICULTURAL PRODUCTS: DEMAND, SUPPLY, PRICES

Robert Anderson, B.S. University of Guelph, 1967; Ph.D. Michigan State University, *Michigan's Purple Plum Industry.*

Choeng-Hoy Chung, B.A.S. University of Malaysia, 1966; M.A. University of Wisconsin, 1968; Ph.D. University of Wisconsin, *Interregional and International Economic Analyses of the World Feed Grain Economy in 1980 with Emphasis on the U. S. North Central Region.*

Hardev Singh Dhaliwal, B.A. Mahendra College, 1959; B.S. Utah State University, 1963; M.S. Utah State University, 1965; Ph.D. Oregon State University, *An Econometric Investigation of Demand Interrelationships Among Tree Nuts and Peanuts.*

Osman Abdul-Rahman Hakim, B.S. University of

Khartoum, 1959; M.S. University of Arizona, 1962; Ph.D. University of Arizona, *The Effects of the United States Cotton Policy on the World Market for Extra-Long Staple Cotton.*

Richard C. Hoyt, B.S. Kansas State University, 1962; Ph.D. University of Minnesota, *A Dynamic Econometric Model of the Milling and Baking Industries.*

Robert D. Hunt, B.S. University College of Dublin, 1965; M.A. University of Minnesota, 1971; Ph.D. University of Minnesota, *The Contrasted Effects of Quota, Autarky, and Free Trade on U. S. Beef Production and Prices.*

Ivar Kristiansland, B.S. Agricultural College of Norway, Aas, Norway, 1959; M.S. University of Oslo, Norway, 1963; Ph.D. Michigan State University, *An Analysis of Intraseasonal Potato Prices.*

Puraficacion Oña MacDonald, B.S. University of the Philippines, 1961; M.S. University of Hawaii, 1965; Ph.D. The Pennsylvania State University, *Consumer Demand for Dairy Products in the United States, 1955–1969—Quarterly Model.*

Purushotam Lal Wahi, B.S. U.P. Agricultural University, 1965; M.S. University of Illinois, 1969; Ph.D. University of Illinois, *An Econometric Analysis and Temporal Price Equilibrium of U. S. Soybean Oil.*

VI. COOPERATIVES AND COOPERATION

Noel S. P. Rebello, B.S. Madras Agriculture College, 1950; M.S. Indian Agriculture Research Institute, 1963; Ph.D. University of Tennessee, *Agricultural Program Planning to Reflect Potentials of Small Farms with Applications to Mysore State, India.*

Carl Robert Saathoff, B.S. Purdue University, 1966; M.S. Purdue University, 1968; Ph.D. Purdue University, *An Analysis of Member Returns from Cooperative Marketing Pools.*

VII. ECONOMIC DEVELOPMENT, GROWTH AND PLANNING

Antonio Aguirre, Graduate, National University of Tucuman, Argentina, 1967; M.S. University of California at Berkeley, 1970; Ph.D. University of California at Berkeley, *Welfare Cost of Protection —the Fertilizer Industry.*

Bashir Ahmad, B.A. Government College, Lahore, West Pakistan, 1952; M.A. Government College, Lahore, 1955; Ph.D. Michigan State University, *Farm Mechanization and Agricultural Development: A Case Study of the Pakistan Punjab.*

Rais Ahmed, B.A. E.P. Agricultural Institute, 1955; M.S. American University, Beirut, 1964; Ph.D. Michigan State University, *Economic Analysis of Tubewell Irrigation in Bangladesh*

Marvin Sydney Anderson, B.S.A. University of Guelph, 1965; M.S. Purdue University, 1968; Ph.D. Cornell University, *The Planning and Development of Brazilian Agriculture: Some Quantitative Extensions.*

Claudio Barriga, Agr. Engr. Catholic University of Chile, 1958; M.S. University of Wisconsin, 1970; Ph.D. University of Wisconsin, *Management in Cooperative Farming: Its Importance for Agricultural Development, With a Comparative Study.*

Derek Ronald Byerlee, B.Ag.Sc. University of Adelaide, 1966; M.Ag.Ec. University of New England, 1968; Ph.D. Oregon State University, *Agricultural Development and Urban Unemployment: A Simulation Analysis of the Nigerian Economy.*

Suthiporn Chirapanda, B.E. University of New England, 1969; Ph.D. Iowa State University, *Linear Programming Models of Interregional Competition for Economic Planning of Thai Agriculture.*

Elizabeth Louise Banks Erickson, B.S. The Univerity of Western Australia, 1962; M.S. The University of Western Australia, 1966; Ph.D. University of Illinois, *A Linear Programming Model for Analysis of Irrigation Agriculture in Northwest Mexico: A Pilot Study of Three Irrigation Districts.*

Carl Farler, B.S. Berea College, 1958; Ph.D. University of Kentucky, *An Interindustry Analysis of the Florida Economy.*

Juan Antonio Figureras, B.A. University of Miami, 1965; Ph.D. University of Florida, *Agrarian Reform and Agricultural Development in Mexico.*

Carlos O'Brien Fonck, Ing. Agron. Universidad de Chile, 1961; M.S. Cornell University, 1966; Ph.D. Cornell University, *Modernity and Public Policies in the Context of the Peasant Sector: Honduras as a Case Study.*

Halvor J. Kolshus, B.S. Vinterlandbruksskolen, Oslo, 1960; M.S. Agricultural College of Norway, 1965; Ph.D. University of Kentucky, *Modernization of Paddy Rice Farming in Northeast Thailand with Special Reference to Use of Fertilizer.*

Jerry Joe Kropf, B.S. University of Missouri, 1964; M.S. University of Missouri, 1970; Ph.D. University of Missouri, *Social Indicators of Efficiency and Equity Convergence in Four Distressed Regions.*

Larry Joe Martin, B.S. The Ohio State University, 1966; M.S. The Ohio State University, 1968; Ph.D. University of Illinois, *The Impact of Improved Technology on Regional Production and Prices of Major Food Commodities in Uttar Pradesh, India.*

Bernardus S. Muljana, Doctorandus University of Indonesia, 1959; Ph.D. Iowa State University, *The Role of Agricultural Exports in Indonesia's Economic Development.*

Olabisi Ogunfowora, B.Sc. University of Ibadan, 1962; M.Sc. University of Reading, 1966; Dip. Agric. Extension University of Reading, 1967; Ph.D. Iowa State University, *Derived Resource*

Demand, Product Supply and Farm Policy in North Central State of Nigeria.

David Peacock, B.S. Michigan State University, 1962; M.S. Michigan State University, 1968; Ph.D. Michigan State University, *The Adoption of New Agricultural Practices in Northeast Brazil: An Examination of Farmer Decision-Making.*

Claudio Pou, M.A. Universidad Catolica, 1958; Dr. Phil. Universidad Catolica, 1960; M.A.Soc.Sc. Pontificia Universita Gregoriana, 1961; Ph.D. Iowa State University, *Optimal Allocation of Agricultural Resources in the Development Area of Patacamaya, Bolivia. A Linear Programming Approach.*

Monroe H. Rosner, B.A. Queens College, 1958; M.A. Cornell University, 1963; Ph.D. University of Wisconsin, *The Problem of Employment Creation and the Role of the Agricultural Sector in Latin America.*

Ronald Earl Shafer, B.S. University of Nebraska, 1967; Ph.D. Oklahoma State University, *The Net Economic Impact of New Industry on Rural Communities in Eastern Oklahoma.*

Katar Singh, B.S. Agra University, 1961; M.S. University of Illinois, 1970; Ph.D. University of Illinois, *The Impact of New Agricultural Technology on Farm Income Distribution in the Aligarh District of Uttar Pradesh, India.*

Leslie Eugene Small, B.S. Cornell University, 1962; Ph.D. Cornell University, *An Economic Evaluation of Water Control in the Northern Region of the Greater Chao Phya Project of Thailand.*

Otto Vergara, B.S. Rural University at Rio de Janeiro, 1962; M.S. Rural University at Vicosa, 1965; Ph.D. Purdue University, *Highway Improvement and Regional Development with Special Reference to Agriculture: A Case Study of the Rio-Bahia Highway in Brazil.*

Robert Wayne Winters, B.S. Central Michigan University, 1950; M.S. Michigan State University, 1951; Ph.D. Purdue University, *The Regional Distribution of Employment Opportunities in Indiana.*

Richard H. Wood, B.A. Antioch College, 1963; M.A. University of Wisconsin, 1965; Ph.D. University of Wisconsin, *The Agricultural Supply Industries in the Economic Development of the Peruvian Sierra.*

VIII. ENVIRONMENTAL ECONOMICS

Richard Thomas Clark, B.S. University of Wyoming, 1962; M.S. University of Wyoming, 1964; Ph.D. Oregon State University, *Predicted Economic Effects of Environmental Quality Control Policies on Linear Firm Models and an Application to an Irrigated Farm Model.*

Darrell Good, B.S. Southern Illinois University, 1968; M.S. Southern Illinois University, 1969; Ph.D. Michigan State University, *Potential Impact of Environmental Pollution Abatement Alternatives of the Michigan Dairy Farming Industry.*

William Woodward Hall, B.A. Presbyterian College, 1967; M.S. Clemson University, 1969; Ph.D. Clemson University, *The Demand for Environmental Quality: Theory and Measurement.*

Lawrence Thad Horne, B.S. Utah State University, 1957; M.S. Utah State University, 1960; Ph.D. Oklahoma State University, *An Economic Investigation of the Impact of Alternative Insecticide Strategies on Cotton Production in the Sunflower River Basin, Mississippi.*

Adachani V. S. Narayanan, B.S. Banaras Hindu University, 1955; M.S. Banaras Hindu University, 1961; Ph.D. University of Illinois, *Economic Evaluation of the Impact of Selected Crop Practices on Water Quality and Productivity—An Application of Linear Programming.*

Mohammed I. Sulieman, B.V.Sc. University of Khartoum, 1966; M.S. University of Idaho, 1971; Ph.D. University of Missouri, *Economic Implications of the Withdrawal of Diethylstilbestrol from Cattle Feeds.*

Daniel Roderick Talhelm, B.S. University of Michigan, 1964; M.S. University of Michigan, 1965; Ph.D. North Carolina State University, *Analytical Economics of Outdoor Recreation: A Case Study of the Southern Appalachian Trout Fishery.*

Charles Robert Taylor, B.S. Oklahoma State University, 1968; M.S. Kansas State University, 1970; Ph.D. University of Missouri, *Dynamic Economic Evaluation of Pest Control Strategies.*

Harold Hacking Taylor, B.A. Brigham Young University, 1963; M.S. The Pennsylvania State University, 1965; Ph.D. The Pennsylvania State University, *The Economic Impact of Alternative Solid Waste Disposal Systems on Centre County, Pennsylvania.*

IX. FOOD AND CONSUMER ECONOMICS

Farrell E. Jensen, B.S. Utah State University, 1964; M.S. Kansas State University, 1966; Ph.D. Kansas State University, *A Comparison of Demand and Factors Affecting Consumer Acceptance of Fresh and Forzen Meat as Determined from a Retail Market Test.*

Lily K. Lai, B.S. National Taiwan University (China), 1964; M.S. University of Kentucky, 1967; Ph.D. University of Wisconsin, *The Estimation of Effects of Expected Family Income and Socio-Economic Variables on the United States Household Consumption of Food Commodity Groups.*

Franklin James Levinson, B.A. Harvard College, 1964; M.S. Cornell University, 1971; Ph.D. Cornell University, *Morinda: A Study of the Determinants of Malnutrition Among Young Children in India.*

David Richard Long, B.S. Cornell University, 1965; M.S. Ohio State University, 1970; Ph.D. Ohio State University, *Impacts of the Food Stamp Program on Rural Non-Farm Ohio Participants.*

Robert Harvey Nicholson, B.S. University of Delaware, 1966; M.S. North Carolina State University, 1968; Ph.D. North Carolina State University, *An Economic Evaluation of Alternative Food Service Systems for the North Carolina Department of Correction.*

Hans P. Peterson, B.A. Florida State University, 1964; M.S. University of Wisconsin, 1971; Ph.D. University of Wisconsin, *Estimating the Influence of Household Composition on Household Food Expenditures by Adult Equivalent Scales for Households in the United States in 1955 and 1965.*

X. GENERAL ECONOMICS

Odin Kurt Knudsen, B.S. Stanford University, 1966; M.S. Stanford University, 1969; Ph.D. Stanford University, *A Permanent Income Theory of Export Instability.*

XI. HUMAN RESOURCE DEVELOPMENT

Jean Spooner Bowers, B.S. University of Idaho, 1939; M.S. State University of Iowa, 1940; Ph.D. University of California at Davis, *The Employability and Motivation of AFDC Recipients in Yolo County, California.*

Brady J. Deaton, B.S. University of Kentucky, 1966; M.A. University of Kentucky, 1968; M.S. University of Wisconsin, 1970; Ph.D. University of Wisconsin, *The Costs and Returns of Migration from Eastern Kentucky to Cincinnati, Ohio.*

Thomas Elmer Haller, B.S. University of California at Davis, 1959; B.D. Princeton Theological Seminary, 1964; M.S. University of Connecticut, 1962; Ph.D. Purdue University, *Education and Rural Development in Colombia.*

David William Holland, B.S. Colorado State University, 1964; M.S. Colorado State University, 1967; Ph.D. Oklahoma State University, *The Geographic and Income Class Distribution of the Benefits and Costs of Public Education—Implications for Common School Finance.*

Wallace Edgar Huffman, B.S. Iowa State University, 1966; Ph.D. University of Chicago, *The Contribution of Education and Extension to Differential Rates of Change.*

James McKenzie, B.S. University of Toronto, 1962; M.S. University of Guelph, 1966; Ph.D. Michigan State University, *An Economic Analysis of Selected Agricultural Extension Programs in Colombia, South America.*

Freddie Cad White, B.S. Texas Technological University, 1967; M.S. Oklahoma State University, 1969; Ph.D. Oklahoma State University, *A Quantitative Analysis of Factors Affecting Elementary and Secondary Schooling Quality in Oklahoma, with Economic Application for Rural Areas.*

XII. INDUSTRIAL ORGANIZATION

Paul Jerome Hooker, B.S. University of Florida, 1966; Ph.D. University of Florida, *The Gulf of Mexico—South Atlantic Shrimp Industry of the U. S.: An Application of Sub-Sector Analysis.*

XIII. MARKETING AND LOCATION

Chamnien Boonma, B.S. Kasetsart University, 1958; M.S. University of Hawaii, 1966; Ph.D. University of Illinois, *Modelling Rice and Corn Markets in Thailand.*

Wayne Allison Boutwell, B.S. Mississippi State University, 1966; M.S. Mississippi State University, 1968; Ph.D. Virginia Polytechnic Institute and State University, *An Analysis of Grain Storage in a Deficit Area.*

Clark R. Burbee, B.S. University of New Hampshire, 1954; M.S. University of New Hampshire, 1960; Ph.D. University of Minnesota, *Adjustments to Improve the Competitive Position of the Upper Midwest Turkey Industry.*

Steve Garland Conerly, B.S. Louisiana State University, 1959; M.S. Louisiana State University, 1964; Ph.D. Virginia Polytechnic Institute and State University, *An Economic Analysis of Milk Supply Response Under the Virginia Milk Commission Class I Base Plan.*

Joseph Richard Crow, B.S. Oklahoma State University, 1967; M.S. Oklahoma State University, 1969; Ph.D. Oklahoma State University, *Optimal Location of Beef Enterprises Under Current and Projected Conditions—An Interregional Analysis.*

Leroy Davis, B.S. Agricultural, Mechanical, and Normal College, 1967; M.S. University of Illinois, 1971; Ph.D. University of Illinois, *Relationship of Market Structure to Spatial and Temporal Pricing Patterns in the Grain Industry.*

Peter M. Emerson, B.S. Cornell University, 1967; M.S. Cornell University, 1968; Ph.D. Purdue University, *An Economic Analysis of World Corn Trade.*

Noralyn Marshall Ewart, B.S. University of California at Davis, 1964; M.S. Purdue University, 1967; Ph.D. Purdue University, *The Impact of Information on Commodities Pricing—A Simulation Study.*

Arturo S. Flores, B.S. University of Philippines, 1963; M.S. University of Hawaii, 1969; Ph.D. University of Hawaii, *Spatial Equilibrium Analysis of the United States Sugar Industry Under Alternative Policy Measures.*

Donald Gene Frahm, B.S.A. The Ohio State University, 1967; M.S. Purdue University, 1969; Ph.D. Purdue University, *Analysis of Producer, Feed Supplier, and Meat Packer Responses to*

Contractual Coordination in the Hog-Pork Subsector.

Peter Vince Garrod, B.S. University of California at Davis, 1966; Ph.D. University of California at Berkeley, *Service and Employment Implications of Food Distribution: A Study of the Retail Sector, Chile.*

Robert Steven Golden, A.B. Michigan State University, 1966; M.A. California State University at Los Angeles, 1968; Ph.D. University of California at Berkeley, *Optimal Hedging Decisions for Beef Cattle Feeders.*

David Ray Graves, B.S. Louisiana Polytechnic Institute, 1966; M.S. Mississippi State University, 1969; Ph.D. Purdue University, *Optimum Number, Size and Location of Retail Outlets for Marketing Agricultural Inputs in Selected Areas of Indiana.*

Paul Randolph Grimshaw, B.S. Utah State University, 1948; M.S. Utah State University, 1949; Ph.D. Oregon State University, *Economic Considerations for Expanded Feeding of Livestock in the Pacific Northwest.*

Jorge Gutierrez-Villareal, B.S. Universidad de Nuevo Leon (Mexico), 1965; M.S. Texas A&M University, 1967; Ph.D. North Carolina State University, *Investment Alternatives in the Processing of North Carolina Apples.*

John Thomas Haas, B.S. Ohio State University, 1954; M.S. Ohio State University; Ph.D. University of Maryland, *An Economic Analysis of the Effects of Optimizing Hog Shipment Patterns and Market Structures on the Efficiency of A Country Hog Marketing System.*

William McGinnis Holroyd, B.M. and M.M. University of Cincinnati, 1950–51; M.B.A. Indiana University, 1960; Ph.D. University of Maryland, *Number, Size and Location of Plants for a Honey Marketing-Processing Cooperative.*

Robert J. Hopkins, B.S. Tennessee Polytechnic Institute, 1968; M.S. University of Tennessee, 1970; Ph.D. University of Tennessee, *The Wholesome Meat Act and the Tennessee Livestock-Meat Industry.*

Bouwo Marcus Jellema, B.S. Agricultural University, Wageningen, Netherlands, 1965; M.S. Agricultural University, Wageningen, 1968; Ph.D. North Carolina State University, *Analysis of the World Market for Groundnuts and Groundnut Products.*

Rana Anwar Saeed Khan, B.A. University of Punjab (India), 1960; M.A. University of Punjab, 1962; M.A. University of Wisconsin, 1967; Ph.D. University of Wisconsin, *An Economic Analysis of 1980 International Trade in Jute with Special Reference to Pakistan.*

David E. Kunkel, B.S. University of Idaho, 1960; M.S. Colorado State University, 1966; M.S. University of Wisconsin, 1968; Ph.D. University of Wisconsin, *Market Structure, Conduct, and Performance: The Turkish Cotton Textile Industry as a Case Study.*

Gerald Wayne Malone, B.S. Louisiana State University, 1966; M.S. Louisiana State University, 1968; Ph.D. Purdue University, *A Simulation Analysis of the Behavioral and Operational Characteristics of a Fertilizer Supply Firm.*

John Chester Moore, Jr., B.S. University of California at Berkeley, 1968; M.S. University of California at Berkeley, 1970; Ph.D. University of California at Berkeley, *The Least Cost Organization of Cotton Ginning Facilities in California's San Joaquin Valley.*

James Alfred Niles, B.S. University of California at Davis, 1967; M.S. University of California at Davis, 1968; Ph.D. University of California at Davis, *Analysis of Systems of Coordinating Agricultural Production and Processing Operations—with Special Reference to Sugar Beet Scheduling.*

Jacques Pasquier, Lic., University of Fribourg, Switzerland, 1959; Doctorate University of Fribourg, 1962; Ph.D. Purdue University, *Pricing and Planning in the Swiss Dairy Industry.*

Dilipsinha Chintamani Pendse, B.A. Poona University, 1959; B.Com. Poona University, 1961; M.Com. Poona University, 1963; M.S. Utah State University, 1967; Ph.D. Oregon State University, *Interregional and Interseasonal Competition in the U.S. Beef Industry, 1967—An Integrated Analysis.*

Michael Joe Phillips, B.S. The Ohio State University, 1967; M.S. The Ohio State University, 1968; Ph.D. Purdue University, *An Analysis of the Class I Base Plan for Milk.*

Lawrence Donald Schnake, B.S. University of Missouri, 1960; M.S. Oklahoma State University, 1967; Ph.D. Oklahoma State University, *Possible Effects of a Cost-of-Service Transportation Rate Structure on the United States Grain Marketing System.*

Eduardo J. Trigo, Licentiate, Catholic University of Cordoba (Argentina), 1967; M.S. University of Wisconsin, 1970; Ph.D. University of Wisconsin, *Structural Changes in the Food Retailing Market in the Buenos Aires Metropolitan Region of Argentina During the 1960–70 Decade.*

Matthias Konrad Von Oppen, Diplom-Landwirt, Technische Universitat, 1963; M.S. University of Illinois, 1969; Ph.D. University of Illinois, *Optimal Size and Location of Marketing Facilities for Soybeans in India.*

Bernard Yon, Ing. Ag. Ecole Superieure d'Agriculture d'Angers, 1966; Diploma, Centre Universitaire d'Etudes de Communautes Europeenes, 1968; M.S. Cornell University, 1970; Ph.D. Cornell University, *Advertising Expenditure, Time Optimization, and Related Firm Behavior.*

XIV. NATURAL RESOURCE ECONOMICS

Frank Malcolm Anderson, B.Ag.Ec. University of New England, 1968; Ph.D. Oregon State University, *Computer Simulation of a Biomanagement System—The Mendocino County Deer Population in California.*

Douglas M. Byers, B.S. McGill University, 1958; M.S. University of Connecticut, 1968; Ph.D. Purdue University, *Watershed Project Evaluation Involving Multiple Social Objectives.*

David C. Campbell, B.A. University of British Columbia, 1965; M.A. California State University at San Francisco, 1967; M.S. University of California at Berkeley, 1969; Ph.D. University of California at Berkeley, *The Economics of Environmental Policy with Respect to Offshore Oil Production.*

Sean Bun Chin, B.S. University of Wisconsin 1966; M.S. University of Nevada, 1968; Ph.D. University of Missouri, *Exhaustible Resources and Technological Change in the United States Agriculture, 1940–1969.*

Sandy A. D'Aquino, B.S. Simon Fraser University, 1968; M.A. Simon Fraser University, 1970; Ph.D. Colorado State University, *Optimum Allocation of Natural Resources.*

Gurmukh Singh Gill, B.S. Punjab University, 1951; M.S. University of New Hampshire, 1968; Ph.D. University of California at Berkeley, *Demand and Supply of Wastepaper with Policy Implications for Quality of the Environment.*

Larry M. Hammer, B.S. University of Nebraska, 1963; Ph.D. University of Nebraska, *The Economic Potential for Private Outdoor Recreation on Farms and Ranches in Nebraska.*

Milton Lee Holloway, B.S. Texas Technological College, 1966; M.S. Texas Technological College, 1968; Ph.D. Oregon State University, *A Production Function Analysis of Water Resource Productivity in Pacific Northwest Agriculture.*

Howard C. Madsen, B.S. Iowa State University, 1965; Ph.D. Iowa State University, *Future Water and Land Supply-Demand Balances for U. S. Agriculture: A Spatial Analysis Incorporating Producing Areas, Consuming Regions and Water Supply Regions.*

Harry Parks Mapp, Jr., B.S. Virginia Polytechnic Institute, 1962; M.S. Virginia Polytechnic Institute, 1964; Ph.D. Oklahoma State University, *An Economic Analysis of Water-Use Regulation in the Central Ogallala Formation.*

Francis Webb Millerd, B.S.A. University of British Columbia, 1963; M.S.A. University of British Columbia, 1965; Ph.D. Cornell University, *An Evaluation System for the Natural Resource Sectors of the Prince Edward Island Development Plan.*

Charles Lee Moore, B.S. Ohio State University, 1968; M.S. University of Illinois, 1970; Ph.D. University of Illinois, *Economic Analysis of Farm Water Supply in Washington County, Illinois.*

Farid Hassan Nawas, B.S. American University, 1963; Ph.D. Oregon State University, *The Oregon Big Game Resource: An Economic Evaluation.*

Daniel John Palm, B.S. Cornell University, 1965; M.S. New Mexico State University, 1969; Ph.D. The Pennsylvania State University, *Development of Economic Criteria for Regionalization of a Waste Water Management System.*

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EDITOR'S NOTE: The dramatic rise in food prices in the United States during the past year has serious implications for national economic policy, traditional agricultural policy, and the agricultural economics profession. Because of the importance and timeliness of the food price problem and related public policy issues, the editors have broken a long established tradition and solicited the following three papers. These were written as a critique and broadly based discussion of the 1973 *Economic Report of the President* and the *Annual Report of the Council of Economic Advisers.*

A DISCUSSION OF THE 1973 *Economic Report of the President*

The Food Price Problem

G. E. BRANDOW

When the Council of Economic Advisers wrapped up its annual report [2] in January 1973, food prices were rising faster than at any time since 1951. In seven months retail food prices had increased 4.6 percent, wholesale prices of processed foods and feeds 11.3 percent, and farm food prices 13.0 percent. Although food prices had risen less than all other items collectively in the Consumer Price Index since the base year 1967, food was easily the most conspicuous problem in the government's recent efforts to control inflation. With a number of important wage negotiations coming later in the year and an evident desire on the part of the Administration to end price and wage controls, the much publicized increase in consumers' food bills was extremely troublesome.

When this article was written in April 1973, further changes in the highly volatile situation had given the writer the benefit of some hindsight that the Council did not have when it wrote the Report. By the time of publication, more things will be known that could only be guessed at in January. The appropriate question to consider, one should remember, is whether the Council's analysis and proposals were well conceived when made at the turn of the year.[1]

The Report on Food and Prices

Price and wage controls, the Council said, had been invoked because at the stage of economic recovery reached in August 1971, the rate of inflation might well accelerate. "[I]t should be clear that the price rises then envisaged for the period ahead would not be the direct result of excess demand. The price and wage increases would not be equilibrating in the sense that they would be necessary to raise output into balance with demand and attract workers. Firms would have been willing to produce more at existing prices, and workers would have been willing to supply their labor at existing wages, if they could not raise them" [2, p. 52]. "Farm product prices were exempted because they did not conform to the pattern upon which the controls system was based . . . . [D]etermined in highly competitive markets, . . . they adjust continually to equate the quantities demanded and supplied. To repress the price increases in those markets would create shortages and rather than increase supply would probably reduce it" [2, p. 151].

The Council concluded that controls had been generally effective: "In the period since the August 1971 policies were instituted there has been a dramatic deceleration in the rate of inflation" [2, p. 30]. A GNP price index with fixed weights showed a 5.2 percent increase from the second quarter of 1970 to the second quarter of 1971 and a 3.6 percent annual rate of increase between then and the fourth quarter of 1972. The strong advance in personal income—10.5 percent between the fourth quarters of 1971 and 1972—was discussed but given surprisingly little weight as an explanation of inflation. A passage on food prices [2, pp. 39–40] was an exception to the general tone; rising income was recognized to have increased demand for income-elastic foods and to have caused "a strain on the available supply of beef, pork, and certain dairy products." Mainly, however, the increase in food prices was attributed to unfavorable circumstances of sup-

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[1] Data are given for January 1973 at several points in this article. It is assumed that although the Council did not have the exact figures when it wrote its report, it knew their approximate values.

G. E. BRANDOW *is professor of agricultural economics at The Pennsylvania State University.*

ply and to strong export demand [2, pp. 39–40, 57–59, 78–79, 154], as follows:

1. A cyclical low in pork production and a less-than-expected increase in beef production because cattlemen were retaining more stock for expansion of herds. Additionally, the substitution in the 1960's of crop controls without acreage diversion for controls that permitted diversion was said to have slowed down expansion of meat production.

2. Adverse weather reduced fruit and vegetable production sharply.

3. Partly for the foregoing reasons, farm food production declined 2.2 percent in 1972 (a preliminary estimate later revised to 3.1 percent).

4. Reduced food production in Russia, China, and India much expanded exports of farm commodities by the U. S.

5. Devaluation of the dollar and inflation abroad raised import prices, a development not specifically put forth in explanation of higher food prices but presumably applicable to some.

6. Though price spreads between farmers and consumers were controlled most of the time for most foods, there was some room for wider processor-distributor margins. USDA's market basket statistics showed at the time, however, that almost all of the increase in retail prices of domestically produced farm foods after August 1971 had gone to farmers.

The Council's Report built a case for the broad relaxation of price and wage controls announced for Phase III in January 1973. The original control program was intended to be temporary, the Council said. The program had done much to reduce expectations of inflation domestically; and internationally, "by the end of 1972 the American anti-inflation policy had become the marvel of the rest of the world. . . . Largely because of this change the rest of the world is willing to hold increasing amounts of dollars" [2, p. 63]. The program had involved some costs; these had been small so far, but they were likely to be greater in 1973 if the same controls were continued. "The conditions at the opening of 1973 permitted and—if the system was to survive and succeed—required a relaxation of these forms of the system. This is the basic philosophy of Phase III" [2, p. 81].

Phase II controls on food processing and distribution margins were continued, with slight modifications, because of the concern about rising food prices. The Report also pointed to measures taken to expand supply of food and to limit further price advances [2, p. 79]. These included USDA actions to bring more cropland into production in 1973, to free up government owned or financed stocks of commodities, and to suspend remaining food export subsidies. The Cost of Living Council had been directed to review USDA administative actions affecting food supplies and prices.

A lag in the effect of supply-increasing measures on retail food prices was acknowledged but not elaborated upon. A comment, neutral in tone, was made about plans to utilize a just-available report by the National Commission on Productivity on ways to improve productivity in food production and distribution. Expecting that food prices would rise less in 1973 than in 1972 and that cooperation would be obtained with its Phase III price and wage standards, the Council announced a goal of having the annual rate of inflation as measured by CPI down to 2.5 percent or less by the end of 1973 and the unemployment rate down to about 4.5 percent.

General Price Situation

Food prices are the center of attention here, but a few comments about the general price situation as seen by the Council seem warranted.

Since the Council found it necessary to resort to rate-of-change charts to make the slowing-down of inflation under the New Economic Policy readily discernible to the naked eye, calling the effect on inflation "dramatic" involved a certain amount of poetic license. The tendency toward hyperbole was most pronounced in describing the American anti-inflation policy as the marvel of the world. Scarcely had the Report appeared when the alleged willingness of other countries to hold dollars evaporated and the dollar was again devalued. The rhetoric is less disturbing than the false confidence about so important a matter as the strength of the currency.

The Council's rationale for imposing wage and price controls in August 1971 had a good deal of validity. The Council's contention that the economy was less vulnerable to cost-push inflation in January 1973 than it had been in August 1971, however, is hard to accept. The unemployment rate had fallen from 6.1 to 5.0 percent, and manufacturing was operating at about 80 percent of capacity rather than about

75 percent. Labor unions and firms in concentrated industries surely feel more confident of their power in a situation like early 1973 than in one like 1971. The Council's arguments that apprehensions about future inflation had diminished and that the economic climate was more conducive to moderate demands by labor for higher wages were shaky grounds upon which to base its conclusions.

The price rise between mid-1972 and January 1973 was not confined to foods but extended to some other products produced by unconcentrated industries with fairly inelastic supplies. Leather, steel scrap, wool, and—less markedly—lumber were examples of products whose prices were rising more than average. The implications might well be that demand-pull effects were beginning to assert themselves and, given the expected expansion of money demand, could induce substantial inflation in the coming year. Demand-pull and cost-push effects are not clearly separable: conditions favorable to demand-pull are also favorable to cost-push, and higher payrolls generated by administrative escalation of wages add to demand. The Council's opinion that cost-push inflation was at least partially pinched off and that demand-pull was not yet much of a threat was optimistic.

Too little attention had been given in most economic analyses, including those of the Council, to the inflationary implications of dollar devaluation when prices in industrial nations were rising strongly. That foreign trade amounts to only about 5 percent of GNP is no assurance that inflationary pressures transmitted from abroad through a depreciating currency will not be strong. This point is particularly relevant to agriculture, for which foreign trade is more important than for the economy as a whole.

One is left puzzled by the exact reasons why the Council argued for the substantial backing-off from controls represented by Phase III. Did the Council genuinely believe that the threat of inflation had materially diminished? Did it see demand-pull inflation building up and not want (understandably) to contend with it with a program designed to impose mild restraint on cost-push inflation? Did it believe that controls did more harm than good if long continued and wanted to abandon them, as originally intended, regardless of the price situation? Perhaps something of all of these was involved.

Causes of the Food Price Rise

Reasons given by the Council for the increase in food prices between mid-1972 and January 1973 were generally correct. Probably too little emphasis was placed on rising demand, which had been phenomenal for beef for some time. The food stamp plan may have had something to do with the high demand for meat in the past two years although not necessarily with the price *increase* in late 1972. Some evidence suggests that stamps have been used to buy more expensive diets at least as much as to buy more nutritious diets; higher-income families' demand for meat is presumably strongly inelastic, and meat is not diverted to low-income families without an appreciable increase in price. The Council's argument that the farm programs in effect after the mid-1960's were more restrictive, indirectly, on cattle production than the earlier programs was not particularly convincing.

The difficult thing to explain about food prices was the intensity rather than the direction of the change in late 1972. Scarcely anyone had correctly anticipated the extent of the price rise—certainly not this writer. When such surprising things happen, one wants to reexamine his ideas about economic relationships in the market; other developments, e.g., the increase in per capita food consumptions after the mid-1960's, reinforce the desirability of appraising whether events can satisfactorily be explained by past quantitative relationships. The Report gives little impression that such questions had been raised. The Council's staff is small, of course, but presumably it can draw upon the expertise of the Economic Research Service in USDA.

Holding Down Food Prices

At the time the Report was issued, rising food prices realistically threatened to escalate wage demands in forthcoming labor negotiations and to give the wage-price spiral fresh impetus. The food situation could be crucial, therefore, to the timing of the next surge of inflation of industrial prices. But this would be only an episode in the longer-term course of inflation in the United States. When one considers the broad price-making forces at work in the United States, inflation abroad, devaluation of the dollar, and such special circumstances as the energy shortage, the 1973 food situation seems a minor variable in determining where the Consumer Price Index might be a few years later.

The Council looked to expansion of supply as the principal means of holding down food prices. Large stocks of feed grains and wheat in CCC inventory or under loan in mid-1972, together with the 60 million or so acres for which farmers received set-aside payments, had given USDA enormous power to influence market supplies and prices. The Council expressed no opinion as to whether the measures recently taken by USDA to increase output would prove to be adequate. One sees only a subdued suggestion of the tug of war that must have gone on between the Council and the Secretary of Agriculture about food policy, but one gets the impression that the Council was not assuming even indirect responsibility for the projected farm program for 1973 as it then stood.

Surely, expanding domestic production appeared at the time of the Report to be the most promising means of holding down food prices. The effects of program changes on supplies and consumer prices could not be great in 1973, but there seemed to be much potential for increasing feed grain and soybean crops that year. This would reduce feed prices, and the level of livestock and poultry prices reached in January 1973 was sufficient to induce expanded production of such products after 1973 if feed prices could be kept down. Supplies and prices of pork, poultry, and eggs, and to a lesser extent prices of beef and dairy products, appeared to be responsive in 1974 and later to practicable measures to increase crop production in 1973.

Removal or reduction of import barriers was another potential means of affecting prices of certain foods. Tight markets for meat in other countries, traceable in large part to circumstances similar to those in the United States, made this approach not a promising one for the most important class of foods. The limited effect of the suspension of beef import quotas in mid-1972 had already demonstrated the small relief to be expected from foreign meat supplies. With prices of manufacturing milk above support levels, reduction of import barriers on dairy products, especially cheese, might have some impact. Consistent with its noncommittal stance on food supply policy, the Council did not discuss the possibility of going beyond steps already taken to reduce import restrictions.

Possible administrative controls on demand for U. S. food exports included curtailing credit assistance on commercial sales abroad, pulling back on P.L. 480, and outright quotas on food exports. As the Council indicated, export subsidies on foods had already been removed, but no other potential measures were discussed. One outcome of dissatisfaction with high food prices may well be restriction of the terms on which food aid is given abroad, mainly through P.L. 480, and at home, mainly through food stamps.

Export quotas raise complex questions. Domestic supplies of feed grains, wheat, and soybeans could be made ample for any nearby domestic need by refusal to export. But the U. S. has a large foreign trade deficit, an unfavorable balance of payments, and huge amounts of liquid claims against it abroad. Would restricting (not eliminating) farm exports reduce foreign exchange earnings? Not if short-run export demand is inelastic, as may be the case.[2] But what about foreigners' willingness to hold dollars and the international cooperation needed for stability if the U. S. limited the usefulness of dollars by restricting exports? If further devaluation was forced, the long-run consequences for food prices in the United States might outweigh a temporary respite achieved by export quotas. Thus, indirectly as well as directly, the weakness of the dollar made control of inflation difficult.

The Council's argument against continuation of Phase II controls strongly suggested that ceilings on food prices were given little consideration. Continuation of controls on food margins in Phase III was as far as the Council was willing to go in recognition of inflationary forces at work on foods. Probably margin controls of the type used had little effect on either farm or retail prices. A & P's frantic effort to reverse the decline in its share of the retail market by aggressive price discounting perhaps did more to hold down food margins than did the New Economic Policy in any of its phases.

Price ceilings, the Council said, would reduce production. As already suggested here, however, ceilings on meat and poultry prices at January 1973 levels probably would have had little effect on reducing output in the next year or two if feed prices could be brought down by enlarged supplies. A more serious short-term difficulty with ceilings that materially reduced prices might well be a need for formal rationing. Unless enlarged supplies soon brought market prices down, the government might find that in rationing it had on its hands an unenforceable and widely unpopular program.

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[2] John Schnittker argued for this position in early 1973 and proposed export controls if world food supplies tightened further.

Improving Food Production and Marketing

Rising prices often turn public attention to potential improvements in production, processing, and distribution that would be useful to make under any circumstances. The range of types of improvements is wide, for example: standardization of packages and shipping containers to facilitate handling and warehousing, fuller use of rail car and truck capacity, eradication of labor union restrictions on more efficient delivery methods and on meat cutting, abolition of promotion and related costs of no value to consumers, and elimination of oligopolistic and collusive practices tending to raise prices. Frequently, however, the potential percentage reductions in consumer prices are exaggerated, at least by implication; it is not recognized that such gains, where achieved, are one-time price reductions and offer only temporary relief from continuing inflation; and the built-in resistance by interest groups to change and the length of time required for results are underestimated.

Society is well served by such improvements, but they rarely can be considered potent weapons against inflation. It is no derogation of a preliminary staff report by the National Commission on Productivity [1], issued soon after the Economic Report was published, to say that the foregoing generalization applies to it. If concern about inflation brings effective action along lines suggested in the Commission report, inflation will not have been all bad.

Though not mentioned by the Council, a similar hope is that technological advances will lower prices or moderate price increases. The possibilities over, say, a decade probably are much more significant than the gains to be made by improving the operation of the food system without technical progress. But the gains seldom can be forced and are not much responsive to price. Substantial advances have not prevented inflation in the past. For the future, measures to protect the environment and to ensure food safety may add to costs of production and inhibit use of some output-increasing technology. Measures to make the terms on which labor is employed in agriculture more like those in industry may also add to food production costs. In numerous respects, the nation faces trade-offs, not gains everywhere.

Operation of the Farm Program

USDA had a little time, but not much, in which to relax acreage controls on winter wheat after the size and probable effect of the Russian wheat sale became apparent. To expect that such a move to keep prices down would be made by a Secretary of Agriculture in an election year assumes less regard for politics than any Secretary is likely to have. But as expectations of high prices began to spread even to feed grains, which were in ample supply for the 1972 crop year, USDA might reasonably have been expected to announce that, so far as possible, the farm program would be operated in 1973 to provide adequate supplies at early 1972 prices. Such an intention probably would have exerted some check on the rise of grain and even soybean prices and would have made feed prices somewhat less discouraging to hog and poultry producers planning future production in the winter of 1972–73.

Relaxation of restraints on 1973 crop acreage was made in a series of steps suggesting that USDA did not want to be accused by farmers later on of over-reacting to pressure from consumers. Until very late, little margin was provided for the possibility of bad weather or less return of set-aside acres to production than expected. But another risk existed, namely, that crop production would be short in 1973 and that the resulting public dissatisfaction would make it impossible to extend any form of the Agricultural Act of 1970 beyond 1973. The need for the farm program to work both ways—to protect farmers against the penalties of excess production and consumers against avoidable shortages—was becoming apparent.

Some Questions For Economists

The food situation at the time the Council prepared its report was a rare combination of circumstances producing price consequences that few economists fully anticipated or could adequately explain as events unfolded. Does this mean that our information about the current magnitudes of the relevant elasticities needs revision? Probably yes, in part. But it may also be a striking demonstration that the conceptual models we use are overly mechanistic and incomplete. Is the retail price that clears the market for beef or pork at any one time sharply defined? Is what we speak of as *the* price or income elasticity of demand in a particular market really a parameter, or is it merely an approximation of a value that varies erratically over a substantial range? Is the joint effect of several price-making variables materially different from that usually inferred from their separate effects? Can the psychology of markets influence prices even of perishable foods for months at a time? In short, can a better understanding of short-term market behavior be developed, and will it require a more flexible conceptual approach?

An entirely different set of questions relates to prospects for food supply and demand in the future and to implications for agricultural policy. Will farm production capacity in years to come generally be excessive or deficient? We are familiar with the consequences of excess capacity for resource use and farm incomes, but the full meaning of deficient capacity is neither self-evident or fully explored. Probably two statements can be made with some assurance about future agricultural policy. First, whether capacity is, on balance, long or short, stabilization of markets from year to year will be a matter of considerable concern to the public and to farmers. Second, since the future is highly uncertain, American agricultural policy should incorporate strategy capable of dealing with any situation likely to develop; commitment to an assumption either of excess or deficient capacity could be badly mistaken. What a true stabilization policy would be and what a strategy for dealing with either excess or deficient capacity would consist of are questions for which no ready answers are now available.

References

[1] National Commission on Productivity, ***Productivity in the Food Industry: A Preliminary Survey of Problems and Opportunities***, staff report, undated.

[2] U. S. Government Printing Office, ***Economic Report of the President***, Washington, D.C., January 1973.

Implications for Agricultural Policy*

JAMES T. BONNEN

ADMINISTRATION actions and announcements that followed the 1973 *Economic Report of the President* make it quite clear that the rather calm statement on agricultural policy in the *Economic Report* and in the U. S. Budget were the first official signals of several major changes in the Nixon Administration's policy. One change is a shift from a farmer and agribusiness dominated policy for food and fiber to a consumer oriented food policy. The second major change involves a phaseout of certain types of direct government payments, reduction of governmental controls, expansion of output, and return of the farmer to the vicissitudes of the free market combined with a policy of expanding U. S. food and fiber exports to capture a larger part of the expanding world market. The third change is a shift further away from the Department of Agriculture as the locus of real power in decision-making for agricultural policy. These proposed changes have both economic and political implications.

Economic Implications

The first real evidence of a major change in agricultural policy came on release of the U. S. Budget on January 29, 1973, and in the *Economic Report of the President* which was transmitted on January 31, 1973. A Presidential message on "Natural Resources and Environment" transmitted February 15, 1973, addressed itself to agricultural policy. After that, one is dependent on press releases and the straws that Secretary of Agriculture Butz and Secretary of Treasury Shultz have cast into the Congressional cave of winds in the form of testimony.

The 1973 *Economic Report of the President* makes it clear that rising agricultural prices were viewed by the Administration as the primary cause of the increasing rate of inflation during Phase II and that they threatened price stability in early 1973. The report argued that an expansion of food supplies was the best way to reduce food price increases and that agricultural policy must be subordinated to the imperatives of the fight against inflation [5, p. 56, 78].[1]

The *Economic Report* summarizes administrative decisions that were aimed at expanding domestic food supplies and lowering food prices and which had been made by the time the Economic Report was published [5, pp. 78, 154]. After the Economic Report was released, several additional steps were announced. Briefly, these many separate actions amount to the following:

1. *Imports have been expanded* by suspension of import quotas on meat and by substantial increases in quotas for nonfat dry milk and cheese.
2. *All direct export subsidies on food products have been discontinued.*
3. *All government-owned grain stocks are in the process of being released into the private market.*
4. *Farm production is being expanded in 1973* by releasing about three-fourths of the 60 million acres diverted in 1972, increasing rice allotments, and allowing grazing on diverted acreage.

The early loosening of controls on an administrative basis already suggests that a move toward some release of present farm controls might be given formal policy status in 1973 agricultural legislation.

In international trade policy, the Nixon administration counts on expanding agricultural product trade to help meet the balance of payments crisis, which includes our growing import needs for fuel and strategic raw materials [5, pp. 131, 134, 139]. Even though not explicitly stated, they are also obviously counting on expanded agricultural exports to sustain de-

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[1] Descriptive, analytical, or policy discussions of various aspects of agriculture are scattered through every chapter of the 1973 *Economic Report* except Chapter 4, "The Economic Role of Women." This is almost invariably the case since the primary themes of the report are broad and seldom focus on the economic performance and problems of any specific industry. For the relevant discussion on agriculture, see [5, pp. 5–6, 39–40, 56–59, 78–80, 131–139, and 151–154].

mand and avoid the farm income losses that might otherwise eventually follow removal of direct production controls and the easing of farm programs to a back seat in national policy. The costs, of course, accrue in those U. S. farm products such as processed dairy foods where the U. S. appears not to have any comparative advantage in international trade and where the choice must be made between protection against imports or exposure to the cold winds of international competition. Only the latter course is compatible with the aggressive free trade policy in farm products which the administration proposes to follow.

The President's message on "Natural Resources and Environment" sets forth his agricultural policy stating clearly the values and the normative social and political goals which the *Economic Report* generally avoids. Presidential messages on agriculture (of any administration) have a unique flavor worth savoring. On February 15, 1973, the President said the following:

> My administration's fundamental approach to farm policy is to build on the forward course set by the 1970 Act. These principles should guide us in enacting new farm legislation:
>
> —Farmers must be provided with greater freedom to make production and marketing decisions. I have never known anyone in Washington who knows better than a farmer what is in his own best interest.
>
> —Government influence in the farm commodity marketplace must be reduced. Old fashioned Federal intrusion is as inappropriate to today's farm economy as the old McCormick reaper would be on a highly sophisticated modern farm.
>
> —We must allow farmers the opportunity to produce for expanding domestic demands and to continue our vigorous competition in export markets. We will not accomplish that goal by telling the farmer how much he can grow or the rancher how much livestock he can raise. Fidelity to this principle will have the welcome effect of encouraging both fair food prices for consumers and growing income from the marketplace for farmers.
>
> —We must reduce the farmer's dependence on Government payments through increased returns from sales of farm products at home and abroad. Because some of our current methods of handling farm problems are outmoded, the farmer has been unfairly saddled with the unflattering image of drinking primarily at the Federal well. Let us remember that more than 93 percent of gross farm income comes directly through the marketplace. Farmers and ranchers are strong and independent businessmen; we should expand their opportunity to exercise their strength and independence.
>
> —Finally, we need a program that will put the United States in a good posture for forthcoming trade negotiations.
>
> In pursuing all of these goals, we will work closely through the Secretary of Agriculture, with the Senate Committee on Agriculture and Forestry and the House Committee on Agriculture to formulate and enact new legislation in areas where it is needed.
>
> I believe, for example, that dairy support systems, wheat, feed grains and cotton allotments and bases—some established decades ago—are drastically outdated. They tend to be discriminatory for many farm operators.
>
> It would be desirable to establish, after a reasonable transition period, a more equitable basis for production adjustment in the agricultural economy should such adjustment be needed in the years ahead. Direct Federal payments should, at the end of the transition period, be limited to the amounts necessary to compensate farmers for withholding unneeded land from crop production.
>
> As new farm legislation is debated in the months ahead, I hope the Congress will address this important subject with a deep appreciation of the need to keep the Government off the farm as well as keeping the farmer on. [3]

In the classical political rhetoric of agriculture, the President promises to free farmers from the oppression of their government. How this is to be accomplished is not completely clear, but sufficient evidence is provided to paint the broad picture. There is a promise to shift away from the old allotment system and its present historical basis to some unspecified but less "discriminatory" base. Price support payments and wheat certificate payments, i.e., income support payments, are to be phased out (subsequently, we learn over a three year period) retaining only the payments made to compensate farmers for holding land out of production. This, of course, should strengthen the Administration's hand in GATT trade negotiations and in pursuing an aggressive policy for farm exports.

The Secretary of Agriculture, testifying March 20 before the House Agriculture Committee and March 29 before the Senate Committee on Agriculture and Forestry, added to these specifics several other recommendations for the Agricultural Act of 1973 [1, 2]. The $55,000 payment limitation is to apply only to price support payments and wheat certificates and is to be scaled down and eliminated over the next three years in proportion as the payments themselves are reduced to zero. The important point is that there would no longer be any payment limitations on diversion payments. At the end of three years the idea of payment limitation would itself vanish from the farm program. The Secretary requested that the 75 percent of parity minimum price support level now in dairy program legislation be removed to give the Secretary greater flexibility. He also requested that the suspension in the 1970 Act of the requirement to provide price supports on butter fat be made permanent. The Secretary's testimony and the State of the Union message taken together make it clear that the administration views the dairy price support system as totally obsolete. Finally, Secretary Butz asked for discretionary authority to set payments for wool and mohair at any level he determines necessary and that the peanut, rice, extra long staple cotton, and possibly tobacco programs, which were not included in the 1970 Act, be examined and possibly included in the Act of 1973.

Much of this sounds very familiar. Previous Republican administrations have talked a lot about freeing the farmer and getting the government out of agriculture, but the Nixon administration apparently means it. They have chosen to include farm income supports (i.e., price support payments) in the Administration's long list of programs scheduled to be dismantled. Production controls are to be put on a standby basis. Some farmers and their organizations are not sure they favor this. The farmer's distress, of course, is a reaction to uncertainty arising from so drastic a change in the rules of the game as well as to the suspicion (in spite of high farm prices) that they are headed back toward the Benson-sponsored choice between income and freedom. Some agricultural economists have expressed concern over the potential disorder that could follow the attempt to "let go of the bear's tail"—to decontrol agriculture. Since many agricultural economists have been saying for years that the farm subsidies have gotten out of hand and that the support program has many deficiencies, why should they be concerned?

The conventional post-1960 economic model

Presumably economists are concerned because of their understanding of the nature of the demand and supply situation that has prevailed in American agriculture for generations and their belief that agriculture is fundamentally different from the rest of the American industrial structure. It is argued that only in agriculture do you find the five general characteristics usually cited since about 1960 as the basis for the uniqueness of agriculture as an industry and for public intervention to meet the problems generated by these characteristics. These are:

1. A low price elasticity of demand at the farm level which in the short run causes very great fluctuations in price and thus income for relatively modest changes in output.
2. At the high levels of income now common in this society, a very low income elasticity of demand prevails for total farm output. As a consequence, demand grows very slowly and is generally limited to population change.
3. At the same time, continuing rapid technological change tends to shift the supply function to the right far more rapidly than demand.
4. This results in a short run downward pressure on prices which, given the highly atomistic or competitive structure of the industry, becomes a long run phenomenon that forces the entire industry to a lower equilibrium.
5. Finally, it is argued that resources once committed (mistakenly in an *ex post* view) become fixed due to a subsequent divergence between acquisition and salvage prices of these assets. This means that once there is an over-commitment relative to future market needs, excess capacity persists. Given the nature of demand and supply, the competitive industrial structure, and persistent excess capacity, there is a continuing downward pressure on prices and income that is chronic.

The consequence of these characteristics is that over time supply shifts to the right faster than demand and that the industry exists in a condition of chronic low returns. Returning agriculture to the free market in the face of such economic characteristics would certainly be a prescription for economic and political disaster.

The Administration's economic model

What has changed? What makes the Nixon Administration think that it can simultaneously succeed in reducing prices, expanding output, and sustaining or increasing farm income? Current changes in short run demand and supply relationships have placed a substantial upward pressure on prices, particularly of meats and other high income elasticity food products. The real question is whether this is a temporary or long term phenomenon. The Administration appears to be betting that a permanent change has occurred in the economic characteristics of agriculture. That question needs to be examined.

The domestic demand for food has expanded, especially for meats, poultry, and fresh produce, as a result of increasing consumer income. Also in recent years, as a consequence of income redistributions, substantially greater income has been placed in the hands of low income consumers. Since 1969, there has been an increase in federal food program subsidies of over 2.5 billion dollars. Given the high propensity to increase food demand among low income families, particularly for livestock products, it is logical to suggest that a very substantial portion of federal food subsidies go to an expansion of livestock product demand. Other income transfers such as Medicare and the large increases in Social Security benefits in recent years are also likely to have had substantial impact on livestock product demand through substitution in low income budgets.

Demand for food exports from the U. S. has also grown rapidly in recent years. Part of this export demand in 1972 is due to the temporary phenomenon of bad weather in China, India, Indonesia, Australia, and especially Russia; this has reduced world grain supplies substantially for 1972. Loss of Peru's fish protein from world markets has compounded this shortage. A more permanent increase in demand for food is being generated by rapidly increasing levels of income in a number of middle income developing countries such as Taiwan, Korea, Mexico, Spain, and Portugal. The United States, as the world's primary residual supplier of grains, has experienced a substantial increase in export demand as a consequence. The poor crop in Russia occurs at a point in time when the Russians appear to have made a major policy commitment to higher levels of living for the consumer and to greater dependence on the outside world for the technology, capital, and resources needed for Soviet economic development. This suggests a long term Russian demand for feed grains, if not some food grains. The stability of Russian behavior and policy in such matters must be questioned on the basis of past experience. At least this time, in the face of an extreme shortage of grains, the Russians chose to import feed grains rather than slaughter their cattle as they have done in every previous instance of major crop failure. The long term meaning of the U. S.—Chinese *detente* for agricultural product trade simply cannot be assessed clearly at this time. But given the level of Chinese development, the presumption must be for relatively limited and only episodic sales of farm products to China. One should keep clearly in mind that high world prices can be expected to provide a powerful stimulus to the enlargement of agricultural production capacity in many countries.

Finally, little has been said yet about the effect of two major devaluations of the American dollar. We have, for example, as a consequence of American devaluation and Japanese upward revaluation of the Yen, reduced the cost of American products to Japan by about one third. Devaluation is a two-edged sword. It increases foreign demand for American food products, but it simultaneously creates domestic price and cost pressures that in the longer term are inflationary and offsetting. Certain food exports to Japan, e.g., pork, have already increased as a direct result of the devaluation. In any case, the cost of American agricultural products has declined in a number of foreign markets. In the longer run, comparative rates of inflation in the United States and in other countries and the relative rates of change in productivity will dominate U. S. export market demand. American agricultural productivity increases over the next few decades may not match the increase in several other countries where currently available technologies are not as fully exploited as in the U. S.

On the domestic supply side, food production fell 3 percent in 1972 but probably will increase some in 1973. In addition, the hog cycle has entered its low production phase.

It is also interesting to note that within this crop year the response to program incentives appears to have been sluggish. The USDA has obviously been quite surprised at the proportion of farmers who opted for the full compliance 25 percent feed grain set aside over the 0 percent set aside, which had been programmed to be more attractive than the former.[3] This and other fragmentary evidence suggests that the excess capacity of recent years may not exist to the degree that it did formerly.

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[3] As a consequence, on March 26 the USDA dropped the 25 percent set aside requirement to 10 percent to "bring feed grain supplies more in line with expected demand" [4].

In specific cases, one can point to evidence of commercial farmer inability to expand output because the labor is not available to operate an expanded plant. Many small farm operators now earning substantial amounts of income from off-farm sources have in the past significantly increased their farm operations in periods of short supply and substantially rising prices. They are not doing so today because the off-farm employment opportunities have grown to be so much more attractive and stable. Part-time farming has itself become a rather stabilized way of life for many of those who for various reasons did not wish to or were unable to adjust to a full commercial operation. Now it appears that they do not have the capacity or perhaps the desire to expand their farm enterprise even in the face of considerable price incentive. Economists have long argued that one of the best public policies for agriculture and rural life was a full employment policy. Perhaps the changes and adjustments of the last several decades have begun to achieve some of the objectives that such statements had in mind. In any case, we no longer have an oversupply of home grown labor, so the opportunity cost of labor in agriculture appears to have risen.

Over the last two decades the ease of entry into farming has been slowly reduced as capital requirements have increased. In addition there is current evidence of far less excess machinery capacity relative to farm land and labor in many highly specialized farm areas. At the same time, demand for farm machinery has been increasing in recent months, and the farmer now faces an eight to 12 month delivery time on many major pieces of equipment. The used machinery market for one and two year old pieces of major equipment has grown extremely active and high priced with many of the most active bidders being machinery dealers themselves.

Pressures of environmental problems have also had an impact. Attempts to control various forms of environmental pollution add to the cost of production in agriculture, shifting the supply function to the left.

Many changes are obvious. The Administration's arguments have some factual bite. A new equilibrium is at hand. There have been substantial increases in demand, both domestic and foreign, relative to supply. Excessive stocks have been liquidated, and the slack is gone from farm production capacity. Any increase in output now must come through an expansion in plant capacity, and that expansion will not occur unless the expected marginal value product of the additional inputs exceeds the acquisition price. If there ever was a moment in recent decades that was auspicious for "turning loose of the bear's tail" of farm controls, this would appear to be it. But how permanent are these changes? Will we turn loose of the bear only to have it turn on us in two to four years?

The Nixon administration spokesmen seem to be saying that there has been a significant and probably permanent change in certain of the economic characteristics that have kept agriculture facing depressed prices and chronic low returns. Their policy actions assume that demand will be shifting to the right over time faster than supply. They clearly assume this will be the case over the rest of Mr. Nixon's second term.

The most reasonable presumption must still be that much of the current change is short run and that the discipline of the post-1960's economic model of agriculture has not been permanently discarded. Until demonstrated otherwise, the prudent analyst must assume that entry is being made into yet another round of the periodic boom and bust cycle in agriculture in which farmers are now being induced to build additional production capacity in excess of some future period's needs. As acquisition and salvage prices diverge significantly, there will again be chronic low returns to resources for some prolonged period until demand catches up with capacity. The presidential elections of 1976 could be the forum for another rather warm farm policy debate, if this turns out to be the scenario. Since the Administration proposes to retain on a standby basis authorization for much the same system of controls as provided in the 1970 Act, they prudently hedged their bets on their economic model of agriculture.

The Political and Organizational Implications

For agricultural policy, perhaps the most single significant long term political implication in the 1973 *Economic Report of the President* is to be found in the following paragraph:

> To help assure that the agricultural policies of government are consistent with the anti-infla-

> tion objectives, administrative actions of the Department of Agriculture affecting food supplies and prices will hereafter be subject to review by the Cost of Living Council (CLC). The CLC Committee on Food has been set up to discharge this function as well as to review or initiate other policies and proposals that may affect food prices. This can lead to a progressive reorientation of agricultural policy to the needs of the 1970's. [5, p. 79]

This and creation of the Council on Economic Policy framework under Secretary of Treasury George P. Schultz may well be the most significant institutional changes in the agricultural policy decision-making structure since World War II. In recent decades the majority of agricultural policy decisions were usually made at a level no higher than the Department of Agriculture, and the participants extended no further than the agricultural committees of Congress, the relevant national leadership of the agricultural lobbies, and the USDA administrators involved. Only on occasions in which these parties continued in dispute or in which the White House saw paramount national interest issues did the White House or its agents effectively force their way into agricultural decisions. However, in the last decade or so the conflict over agricultural policy in an increasingly urban Congress has grown so great that the Secretary of Agriculture has often had to have White House political assistance for passage of general farm legislation. Thus the locus of farm policy decision has been slowly drifting toward the White House.

As a consequence, by the 1970's the Office of Management and Budget (OMB) had acquired a nearly routine right to review agricultural policy decisions, especially those which had any impact on the budget. The Council of Economic Advisors' (CEA) agricultural economist usually participated in this review also. Several points of view, beyond USDA concern for food and fiber firm welfare, come into focus in this review. OMB tends to reflect the interest and viewpoint of the taxpayer. CEA's views are informed by a concern with efficient resource use and policies to promote national economic growth and stability. The Council's concern for stability made it the usual, but generally ignored, voice of consumer interest in agricultural policy. With a major inflation upon us, the injection of the Cost of Living Council (CLC) into this review of agricultural policy introduces a major vigorous proponent of the consumer's interest in all policies that influence food prices.

Every decision of national policy consequence in agriculture now must go either to OMB (e.g., commodity programs) or CLC (e.g., marketing orders) which coordinates and mediates the inputs of the other White House agencies. Moreover, the White House is now in a far stronger position to initiate action as the CLC did in raising cheese import quotas. Unresolved issues can be taken to the President's Assistant for Economic Affairs, Secretary of Treasury George Shultz, for resolution, and where necessary, all the way to the President. More symbolically, the administration spokesman in press conferences and in testimony on the hill on agricultural and food prices during the first part of 1973 has more frequently been George Shultz than Earl Butz. The Secretary of Agriculture appears not even to have been a party to the March 1973 decision to impose wholesale and retail price ceilings on beef, pork, and lamb. In the Executive Branch, the real power of agricultural policy decision making has been substantially removed from the hands of the agriculturalists.

Reduced agricultural access to the power of decision is believed by many in politics to be overdue, since the execution of agricultural policy decision making has steadily been drifting away from the national interest and periodically exhibits great callousness to and ignorance of the consumer and national interests in farm policy. There are, however, substantial dangers in the present situation even from the point of view of the national interest. It does little good to transfer the power of decision from agriculturalists, however self-serving, to those who lack adequate knowledge of the food and fiber industry. The unskilled surgeon is even more dangerous to the patient than the one who is unconcerned for the patient's well being. It is one thing in an inflationary crisis to assert the dominance of the consumer and thus the national interest in keeping food prices from running away. That is an emergency political act. However, if the long term management of food and fiber policy is to remain totally in the hands of White House agencies such as the Cost of Living Council, one must be concerned for the quality and wisdom of complex policy decisions that can be made without a large, specialized, and experienced staff. The Cost of Living Council is now putting together a staff which, even if it is four times the combined CEA's one and OMB's seven or so persons in agricultural policy, still leaves the White House well short of an adequate staff with which to replace the USDA.

Conclusion

The Nixon Administration clearly plans a major transformation in U. S. agricultural policy. For decades the U. S. has been evolving from a producer dominated farm policy to an industry oriented total food and fiber policy. In the face of the political crisis generated by current inflation, the farmer and business interests of the food and fiber sector are now being subordinated to those of the consumer. In effect, a consumer food policy now exists. Whether it will remain so indefinitely is not clear. But experience in such matters suggests that a return to the former decision making situation is unlikely and that the consumer's voice will remain at least a major input in the agricultural policy decision making process. The consumer's voice will certainly remain strong if the Administration's expectations are realized and demand continues to press on supplies.

The Nixon Administration is also asserting the importance of international trade and trade policy in domestic agricultural policy decision making. If the Administration succeeds in moving U. S. agriculture to a free market posture, with price supports and production controls shifted to standby, the role of U. S. farm exports will be critical both to farm income and to the success of the new public policy for agriculture. After moving in this direction, U. S. domestic food and fiber policy can never again be formed independently of U. S. trade policy.

Within the food and fiber industry, different groups will react differently to this proposed change in policy. Under the agricultural policies of the last several decades, there has been growing conflict of interest between farmer income goals (based on restricting farm output) and the welfare of other food and fiber firms, particularly those marketing farm products, where profits are keyed to margins and usually depend on expansion of physical volume for any improvement. Certainly large food and fiber firms that market farm products will tend to support any change toward a policy of output expansion. Among the farm organizations, the American Farm Bureau Federation has long been supportive of the kind of policy the Administration is proposing. The National Farmer's Union and the National Farmer's Organization are almost certain to be opposed. The more pragmatic Grange position is hard to anticipate. Certainly this change in policy direction will not be greeted with cheers in the Democratic dominated agriculture committees of Congress, because of partisan political reasons and because many of the commodity groups with whom the senators and congressman must work are likely to be very leery of facing the income uncertainties of the new policy. Dairy interests and other groups that must meet even greater import competition will be vociferously opposed. Wheat, feed grain, and other groups with major export interests should be supportive, while the rice people will as usual oppose all change on principle. How this will work out in Congress is difficult, if not impossible, to assess at this point in early May of 1973.

To enforce this policy transformation, the Executive Branch decision structure for agricultural policy has been transformed, probably in some degree permanently. The Council of Economic Advisors, the Office of Management and Budget, the Cost of Living Council, and the Council on Economic Policy now intervene as primary forums within which all economic policy decisions are looked at from various aspects of national interest. This cuts through the classical cabinet agency-clientele dominated decision process. Neither agricultural policy nor any other national economic policy decision making process will ever be quite the same again. Whether this leads to improved or more rational national economic and agricultural policies remains to be seen.

Subsequent Events and Observations[3]

Traditionally, many congressional agricultural committee staff functions, particularly in policy and program evaluation, have been performed by the staff of the U. S. Department of Agriculture at the direction of the committees. In centralizing the Executive Branch decision process in recent years, the Nixon Administration has acted to limit if not halt most cabinet agency communication and cooperation with committees of Congress. In effect, the Nixon White House has stripped the USDA of its freedom to act on policy both in the Executive

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[3] The galleys of this article arrived for editorial review July 30, 1973. By this time the situation in Congress was clear and so unusual that additional comment was felt necessary.

Branch and in Congress and has denied Congress its traditional access to USDA staff capacity. This tends to short circuit the action agency-clientele-congressional committee dominated decision triangle that has for so long provided the means of locking the President (and on occasion even the Secretary of Agriculture) out of specific policy decisions.

However, the White House, having acquired nearly exclusive power of Executive decision and having formulated a responsible and thoughtful agricultural policy position, then totally abdicated its legislative leadership role. In April and May as the White House was more and more deeply implicated in the Watergate burglary, a conscious decision appears to have been made in the White House to expend no Presidential political capital in Congress to obtain enactment of the Administration's well formulated legislative goals in food and fiber policy. As a consequence the administration's legislative proposals were given no serious consideration in Congress since the Administration was unwilling politically to support its own proposals. In short, the White House by its own actions created a power vacuum in food and fiber policy in Congress.

Into that vacuum, the farm commodity interests moved. Congressional Committees and individual congressmen, denied the usual USDA staff support for their own policy analysis and development and in the absence of aggressive executive branch policy leadership, became quite vulnerable and nearly totally dependent upon the specialized farm commodity lobbies. There was neither staff policy analysis nor alternative political forces present to provide a countervailing force to commodity interests in Congressional negotiations. The Senate produced a bill by late June which the Secretary of Agriculture immediately endorsed as if it had been his own creation. One wonders if the Office of Management and Budget, the Cost of Living Council, or the Council of Economic Advisors shared his enthusiasm.

The potential legislative outcome of its own deliberations were so distressing to the House Agriculture Committee that in late June and early July, it was reported that members of the Committee pleaded repeatedly with the White House for a statement threatening a Presidential veto if the House passed legislation with price targets at the very high levels then under consideration in the House Committee. A reluctant and not entirely credible statement was finally elicited. The House and Senate have now acted, and 1973 agricultural legislation is in Conference Committee. The Senate Bill particularly can be described as a victory for the specialized commodity interests and a step backward in intelligent policy for agriculture. When contrasted with what the Administration originally proposed, we have clearly missed a significant opportunity. As long as demand for food presses on supply as greatly as at present, these bills can have only limited impact. But if and when market prices decline and inventories begin to rise, there is considerable potential mischief in these bills both for the taxpayer and the consumer and ultimately for the farmer.

As the Watergate investigation has disordered the White House, many previous restraints on cabinet agency heads have eroded. But the Secretary of Agriculture appears to have little stomach for the task. Besides, it is probably too late. The agriculture bills are in conference and the damage mostly done. Only the most vigorous and unified action by the Administration in the Conference Committee can eliminate the worst features of these bills.

The food and fiber policy scene today is unstable and volatile. It will achieve stability only when the formulation of food and fiber policy systematically and fairly takes into account the interest not just of the farmer alone or the food and fiber industry or the taxpayer or the consumer, but all these parties. This will never occur without strong Executive Branch leadership.

References

[1] Butz, Earl L., Statement before the Committee on Agriculture, U. S. Congress, House of Representatives, March 20, 1973, USDA press release.

[2] ———, Statement before the Committee on Agriculture and Forestry, U. S. Congress, Senate, March 29, 1973, USDA press release.

[3] Nixon, Richard M., State of the Union Message on Natural Resources and Environment, Washington, D.C., Feb. 15, 1973.

[4] U. S. Department of Agriculture, "1973 Feed Grain Program Set-Aside Requirement Reduced," press release 949-73, March 26, 1973.

[5] U. S. Government Printing Office, *Economic Report of the President*, Washington, D.C., Jan. 1973.

Implications for Agricultural Economists*

JAMES S. PLAXICO AND DARYLL E. RAY

THE tone and substance of the 1973 *Economic Report of the President* [8] implies a number of short-run indictments and longer-run challenges to the agricultural economics profession. The Brandow [2] and Bonnen [1] discussions of the food price issue and the agricultural policy implications of the *Economic Report* also provide background for discussing future professional activities.

Implied Indictments of the Profession

Even with all the sophisticated models and analytical expertise within the profession, agricultural economists failed to anticipate the magnitude of food price increases during late 1972 and early 1973. A part of the relative shifts in supply and demand that caused the price rises was due to adverse weather which reduced farm production and lowered rates of gain for livestock, plus unforeseen production failures in importing countries—influences that economists often assume away or declare exogenous. But the lagged effect of past crop production levels, the positioning of hog and cattle cycles, changes in per capita purchasing power and its distribution, and long term export indications are the sorts of phenomena that are part and parcel of professional agricultural policy and price analysis. Yet agricultural economists provided little insight during the fall of 1972 of the impending crunch in supply relative to demand. One must assume either that the profession does not have properly specified economic relationships and reliable estimates of the structure for the modern-day market for agricultural products or that the basic analytics of the current market though available and reasonably accurate were not utilized in a conscientious and integrated fashion. The Council of Economic Advisers implies that the former was true. The market relationships, they would contend, are unlike the structure of old. Thus, it would be erroneous to apply directly or indirectly the supply elasticities and demand elasticity matrices developed during the late 1950's and 1960's in analysis of present-day agriculture. If all this is true, the analytical expertise of the profession is indeed badly in need of repair.

While substantial changes in many individual economic relationships undoubtedly have occurred, it is puzzling that fairly comprehensive studies, reported as late as 1971 [3], do not seem to indicate a general transformation of the agricultural demand and supply structure. Perhaps the primary reason for surprise over food price increases was a combination of lack of effort by agricultural economists and the unforeseen influences mentioned earlier after all. But whatever the true explanation, it could be argued that the profession did not do its job. If the economic relationships are indeed reasonably valid and the expertise exists, why did the profession fail? Was it lack of coordination or leadership? Even if policymakers could not have altered the events of last year had we anticipated them correctly, our lack of informed analysis diminishes our creditability for future council.

Another implied indictment against the profession made in the *Economic Report* relates to a fundamental concept in agricultural policy—excess productive capacity. Here again the Council of Economic Advisers admonishes the profession, implying that the concept of excess capacity is as antiquated as the closed door China policy. Perhaps the Council is right or is at least partially correct in the sense that the magnitude of excess productive capacity may be considerably smaller than during previous decades. While studies have suggested that excess capacity averaged about 6 or 7 percent during the 1950's and 1960's, we are unaware of a comprehensive study that reports the extent of excess capacity in the 1970's. It is obvious that citing excess capacity percentages for previous decades would not impress the Council. Many in the profession could make an educated guess of current excess capacity, but unfortunately we do not have the necessary research to deliver a timely and reasonably precise estimate. More significantly, the Council staff in all likelihood does not have the estimate either.

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Yet, they are near the fulcrum of the policy making process while we are often on the outside fringes. But within the profession, distance from the center of power and influence is no excuse. Aside from a few up to date "free market" studies which indirectly address excess capacity, we simply do not have up-to-date evidence that unequivocally endorses or refutes the "evaporation of excess capacity theory." Perhaps some would contend that we are so busy incorporating the latest statistical innovation in sophisticated but all-too-often insignificant models, that we overlook the really important questions that need answering. On the other hand, the continuing reality of excess capacity may be so obvious that the profession sees nothing to be gained from beating a dead horse. Nonetheless, the 1973 *Economic Report of the President* and subsequent administrative declarations on agricultural policy suggest that there is a need for an on-going study that empirically estimates the current extent of excess productive capacity in agriculture.

A final apparent indictment made by the *Economic Report* is that we have not sufficiently been concerned with consumer interests in policy analysis. Perhaps most of us will have to plead guilty on that count and hope that during our suspended sentence we can "right" our ways. A standard excuse is that consumer prices can be calculated on the side, by those interested in such numbers, from farm level prices with the use of margins. But by not always reporting consumer prices, the full impact of a policy change is masked. A corollary to this indictment is that we take a myopic view of agricultural policy when we should view it as one component of an overall economic policy. Again, there is some validity to this observation, and gaining a broader view of policy seems to be one of the challenges the profession must meet in the years ahead.

Challenges for the Profession

Clearly, the major impetus for a changing thrust of professional activity should be more deeply rooted than a knee-jerk reaction to the latest crisis or the most recent issue of the *Economic Report of the President.* But to the extent that both dramatize or signal a permanent change in the philosophic base of economic policy, they may provide the capping evidence that there is a need to broaden and reevaluate the professional activities of agricultural economists.

With the political and economic environment of modern day agriculture, the profession is being encouraged to view the entire food and fiber complex within the framework of the national economy. Detailed estimates of farm commodity prices and incomes and of total and average per farm net income for alternative food policies will no longer be sufficient. Such analyses must also trace the direct and indirect effects of public policies on rural communities, agribusiness, taxpayer cost, and most especially on consumer prices. While farm level estimates and gross indications of taxpayer cost and consumer food expenditures have provided an adequate information set for agricultural policymakers in the past, policymakers of the future will likely view their constituency as being the entire society and not just the agricultural industry. Hence, an analysis that fails to treat the consumer food price issue extensively will be ineffective.

But agricultural economists cannot afford to be unduly intimidated by the accelerated move toward a consumer orientation of agricultural policy. While examination must be made of the ramifications of policies on such items as retail food prices, the Consumer Price Index, and U. S. ability to buy foreign oil, responsible policy actions cannot be pursued solely on the basis of their favorable impact on such variables without regard for the economic health and the long run viability of the agricultural sector and rural communities. Perhaps one of the greatest challenges for the profession will be to provide economic policymakers with a balanced and thorough food policy analysis that forcefully addresses the equity question. To be effective, the distribution of relative cost and benefits among the components of the production agriculture-rural community-agribusiness-taxpayer-consumer complex and among the income and social strata within each group should be routinely supplied to policymakers in the future. The time horizon of analysis must be long enough to insure balance in the considerations of short-run and long-run benefits, costs, and distributional effects of the policy under consideration. To the extent that the policymaking process becomes increasingly concentrated in the upper reaches of the executive branch, the magnitude of this challenge heightens.

The set of policies analyzed by agricultural economists will, in all likelihood, include not only those aimed directly at agriculture (with their nonfarm effects) but also those policies that relate more directly to society at large or to other societal components that also have income, structural, or performance implications for agriculture. Too little research attention has been directed toward an understanding of the impact of changes and policies in the general economy on the agricultural sector. For example, the overall and the direct impact of inflation on agriculture is very poorly understood. In like manner we have a very rudimentary understanding of the direct and indirect impacts of monetary and fiscal policies on agriculture. The implications of direct price controls in the general economy and agriculture are largely a matter of speculation. Research on the future organization, structure, and control of agriculture is of prime interest to agricultural producers. Just as analysts cannot ignore the nonfarm influences on future farm structure, neither can the social and economic implications of alternative structures on nonfarm groups be ignored.

To achieve success in integrating analysis of the agricultural sector with the national economy, we obviously must develop a more systematic and complete description of the agricultural industry itself. In the past much emphasis has been directed toward estimation of structural supply and demand parameters for farm commodities. As a result, the profession has amassed considerable information relative to individual commodity relationships. Yet we have limited insight concerning the overall internal workings of the food and fiber markets. The research and marketing act of 1946 may be viewed as Congressional response to societal demand for research directed to a better understanding and eventual coordination of the food and fiber marketing system. Unfortunately a major share of these funds has been allocated to noneconomic related research [7]. As a consequence we have produced a very refined description of marketing channels of several commodities. We know something about transport costs in specific situations and have produced a great volume of results relating to regional comparative advantage within the assumptions of traditional transportation and spatial equilibrium models. But we know relatively little about how the overall food and fiber system operates or how it is coordinated. This is true of both the factor markets which deliver inputs to producers as well as product markets that deliver food and fiber to consumers with appropriate regard for time, place, and for utility.

Evident and long recognized is the need to integrate the work relative to individual commodities, factor markets, and marketing into a comprehensive description of economic activity from the time production decisions are made to the sale of the final product [5, 6]. This overall or system-oriented approach does not mean that work on individual commodities should necessarily be deemphasized. The validity of such a system approach will depend to a large extent on the validity of subsector components of the system. The doubt that has been cast on the appropriateness of applying past quantitative market relationships to analyze current market developments underscores the need for on-going work on commodity market relationships. Thus, commodity and marketing channel researchers must provide important input into the development and continuing structural revisions of the system model if the submodels are structured so that they can constitute a part of a systems analysis.

Transportation represents a major item of cost in producing and delivering food and fiber to consumers. Frequently it has been suggested that a reorganization and restructuring of the industry might offer a major opportunity for enhancing the productivity of the food and fiber industry. Yet, comprehensive studies by agricultural economists of the transportation industry are conspicuous by their absence. Nor have the findings of transportation economists been brought to bear on agricultural marketing problems. Clearly, if we are to develop a reasonable understanding of food and fiber systems, much work remains to be done in the economics of transportation area.

Although production agriculture remains relatively untouched by the labor union movement, a very large proportion of the nation's food and fiber is affected by union work rules before it reaches the final consumer or is exported. Yet agricultural economists have given little attention to the impact of various labor arrangements on the food and fiber system. Any meaningful systems view of the food and fiber complex must include such analyses as input.

Export markets and trade policy are likely to be an ever-important consideration in the formulation of food policies. Generalized deductions of probable commodity exports that may increase in the future based solely on policy statements of foreign governments (which is about as specific as agriculture economists have seemed to be) will not suffice. Even with the short-run influences of weather and the political and institutional uncertainties that surround foreign trade, there is an obvious need to develop long-term price-quantity commodity export demand schedules for individual countries based on informed and meticulously researched supply and demand developments in each of the major importing countries. The degree of success in such an endeavor could mean the difference between economic health and economic chaos for production agriculture.

The furor over high food prices and optimistic export expectations has provided the current administration with a politically appealing backdrop for dismantling the present agricultural production control and price support programs. But even after discounting for the conservative bent of the present administration, it seems apparent that agriculture is destined to move toward a freer market posture. The profession must gear up quickly if it is to anticipate and analyze competently the short-run and longer-term effects of free markets on production agriculture and rural America. While free-market studies of agriculture appear frequently, there is a question of whether the historically based supply and demand response parameters used in such studies are valid if all agricultural commodities are decontrolled simultaneously. Lacking assurance as to price and income, would the financial community finance the expansion of agriculture that is indicated by free-market studies? In light of current and expected market developments, what is the extent of excess capacity of American agriculture? If a free market does bankrupt agriculture, who will pick up the pieces? Would such an event set the stage for the takeover of agriculture by nonfarm corporations or large-scale cooperatives? What are the long-run food price implications if agricultural production is eventually controlled by a few large entities? What would be the economic outlook for the hundreds of thousands of farmers who would be pushed simultaneously into the nonfarm labor market, assuming there is substantial excess productive capacity? If the American people felt a moral responsibility to ease the psychological and economic trauma of displaced farmers and rural businessmen, what programs should be instituted? These questions, of course, are not new, but with a fundamental redirection in agricultural policy there may be an unprecedented urgency for researching the answers.

While distributional considerations do not seem to be at the forefront of the current administration's thinking, programs to help farmers make necessary adjustments and rural development programs in general would seem to require an equity foundation. Much work in rural development has concentrated on industrialization and recreational development. But if adjustment analysis and rural development are to have an equity foundation, the distributional facets must receive central attention in the planning, execution, and evaluation stages of farmer adjustment and rural development programs. Firms locating plants in rural areas provide job opportunities for unemployed and underemployed community residents. The community also benefits directly via the multiplier effect through increased demand for goods and services. But few communities have the resource base necessary to attract new plants, and the gains in the communities where plants do relocate do not reach all population strata. A narrowly framed concept of rural development designed to generate increased economic activity and employment in the most favored communities of rural areas may not alleviate the most serious inequities—only reduce their geographical focus. A regional goal of increased economic growth—without regard to its distribution among small and large communities, skilled and unskilled workers, the young and old, the economically advantaged and disadvantaged, and other population strata—may raise average per capita incomes in the region, but this is not complete rural development in the equity sense.

A multipronged or systems approach to rural development is essential if the objective is to erase the inequities of national economic policies that falls on rural communities and the various economic and social groups in them. Viewed from the equity dimension, rural adjustment and development researchers should identify the nature, location, and extent of inequities falling on farmers and rural communities and the various population groups, and then suggest alternative means of alleviating the inequities [4].

Conclusion

It seems clear that agricultural economists will increasingly push their work perception beyond the confines of a closed view of the agricultural sector. The nonfarm ramifications of agricultural economists' activities can no longer be slighted or ignored. As the profession places more emphasis on overall economic interrelationships, perhaps, our more difficult task will be to gain an audience with future economic policy czars so we can present our "balanced analyses" and help insure that agricultural interests are not completely subordinated to other concerns.

References

[1] BONNEN, JAMES T., "A Discussion of the 1973 *Economic Report of the President:* Implications for Agricultural Policy," *Am. J. Agr. Econ.*, this issue.

[2] BRANDOW, G. E., "A Discussion of the 1973 *Economic Report of the President:* The Food Price Problem," *Am. J. Agr. Econ.*, this issue.

[3] GEORGE, P. S., AND G. A. KING, *Consumer Demand for Food Commodities in the United States with Projections for 1980*, University of California Giannini Foundation Monograph 26, March 1971.

[4] HEADY, EARL O., "Elements in Making Rural Development Go," in *Increasing Understanding of Public Problems and Policies—1972*, Farm Foundation, 1972.

[5] SCHRUBEN, LEONARD W., "Systems Approach to Marketing Efficiency Research," *Am. J. Agr. Econ.* 50:1454–1468, Dec. 1968.

[6] SHAFFER, JAMES D., "Changing Orientations of Marketing Research," *Am. J. Agr. Econ.* 60:1437–1449, Dec. 1968.

[7] SMITH, GLENN R., "Has Social Science Research at the Experiment Stations Increased in Line with Society's Need and Congressional Intent?" paper presented at the American Agricultural Economics Association Annual Meeting, University of Florida, August 1972.

[8] U. S. Government Printing Office, *Economic Report of the President*, Washington, D.C., Jan. 1973.

System Simulation of Agricultural Development: Some Nigerian Policy Comparisons

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The generalized system simulation approach can improve information input to the decision-making process in general. This paper illustrates a particular application to problems of planning and policy making for agricultural sector development. An overview of a simulation model of the Nigerian economy is given, and results of a series of 15 Nigerian agricultural development policy simulation experiments are analyzed in detail. The main conclusion is that, at least for these 15 experiments, a technological transformation of agricultural export crop production is necessary for sustained economic growth. The paper concludes with a discussion of the approach's general applicability.

A MICHIGAN State University team of agricultural economists and systems scientists has recently developed a computer simulation model of the Nigerian economy [6]. Although Nigeria was chosen as the specific focus for the work, the contractual objective of this effort was generally to develop and assess further the capability of simulation models to be used in agricultural sector planning as an aid in evaluating the likely impacts of adjustments in agricultural structures and policies. In previous papers [3, 4] both the basic methodology used by the simulation team has been described, and some features of the dynamic computer simulation model of Nigeria have been considered. While the model's general structure will be summarized briefly here, the main objective in this paper will be to illustrate the model's potential usefulness by simulating likely consequences of 15 agricultural policy alternatives for Nigeria. Policies are evaluated by comparing their effects on several performance variables—gross domestic product, export levels, value added, and nutrition levels—which development administrators may consider important. Although the simulated results reported here must be considered tentative and subject to change as improved estimates of available resources and behavioral relationships are developed, they do illustrate how such a model can be employed when adapted to similar situations in other countries. For Nigeria in particular, to the extent that the simulation model faithfully represents the actual behavior of the Nigerian economy, the results may also provide insight into the comparative adjustments likely to occur under these postulated conditions. The paper concludes with a discussion of the current stage of model development and the model's applicability to agricultural planning and/or policy formulation.

Description of the Model

The problems of potentially relevant policy-making clientele determined which sectors and interrelationships needed particular attention within the model and which level of aggregation was required. Resulting major sectors and flows incorporated within the simulation model of the Nigerian economy are shown in Figure 1. As seen in the diagram, emphasis is on the agricultural sector. Since agriculture is dominant in the Nigerian economy (contributing 65 percent of the gross domestic product and 66 percent of Nigerian exports in 1962–63) and in most less-developed countries, its role in future growth will be very important.

Planners in less-developed countries are interested in evaluating alternative policies (often involving economic incentives or government assistance of various kinds) affecting regional specialization of production and trade. To permit consideration of simple questions related to regional specialization and interregional trade, a two-region (North and South) commodity-oriented model was conceived. Several ecological zones within each region were also differentiated to permit more detailed consideration of problems encountered within the two regions. The orientation toward both annual and perennial commodities as well as the definition of distinct ecological zones and regions makes the

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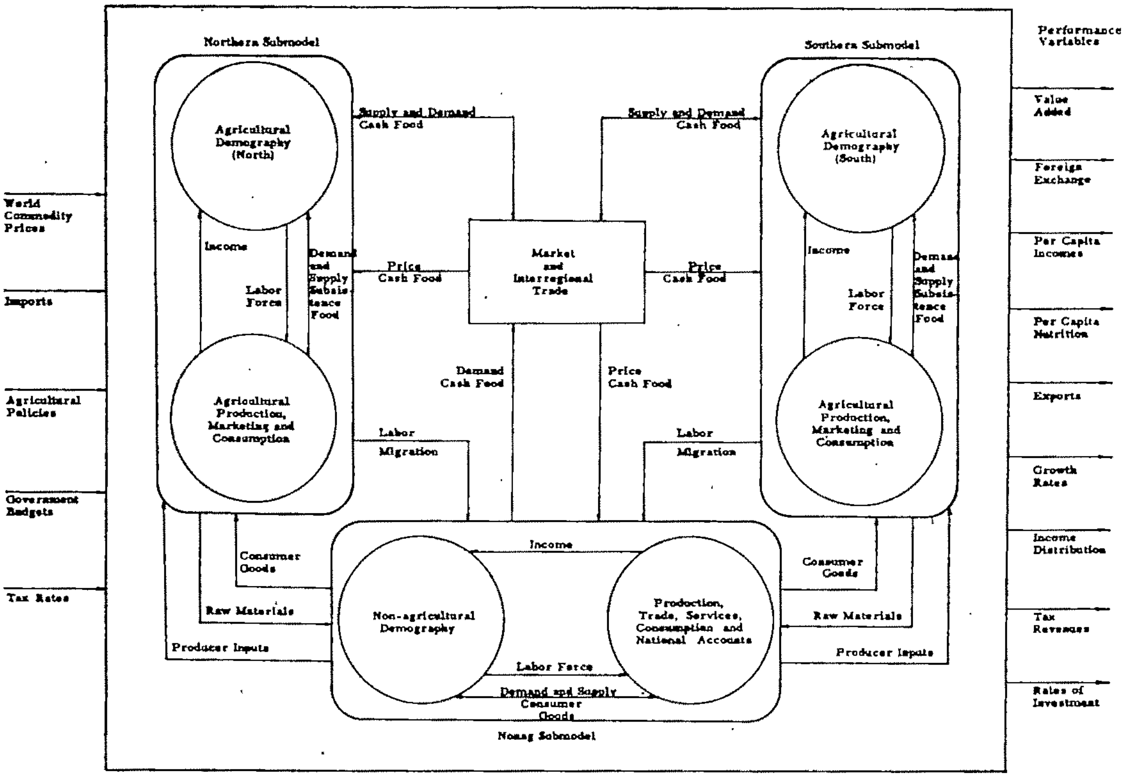


Figure 1. National model of interacting submodels, Nigeria

model's components adaptable to a broad range of countries in accordance with the objectives of the AID contract under which the work was conducted.

Three major submodels compose the simulation model of the Nigerian economy: the northern regional agricultural submodel, the southern regional agricultural submodel, and the non-agricultural/national accounts submodel. In addition, there are components which model the national food market and population dynamics.

Agricultural sector submodels

Basic component structures of the two agricultural submodels are quite similar, as is evident in Figures 2 and 3. The nature of perennial commodities, however—trees exhibiting demographic characteristics of gestation, growth, maturity, and decline—considerably complicates the southern submodel, particularly in the land allocation and modernization component [1, Chapters 2 and 3].

Briefly, the agricultural submodels allocate land to the available commodities (indicated in Figs. 2 and 3) based on profitabilities perceived by farmers and subject to input constraints. Commodity yields are determined by the traditional-modern technology mix and by producer prices. From land allocations, commodity yields, and given technological coefficients (e.g., factor input rates and marketing losses), the total production of each commodity is determined, as are subsequent marketing and processing functions. Agricultural processing in the North is modeled with input-output ratios. Because of the significance of palm and rubber processing activities to the agricultural producers in the South, processing in the southern submodel is modeled in considerably greater detail. Finally, economic performance criteria are generated, and the agricultural sector budgets are accounted in each region.

An additional component of the northern submodel, cattle production, simulates the meat and milk production process in traditional and modern herd management situations by using inputs of total digestible nutrients (TDN) from the production of forage and grain crops. The main interaction between the cattle and annual crops components in the northern submodel occurs in the land allocation component,

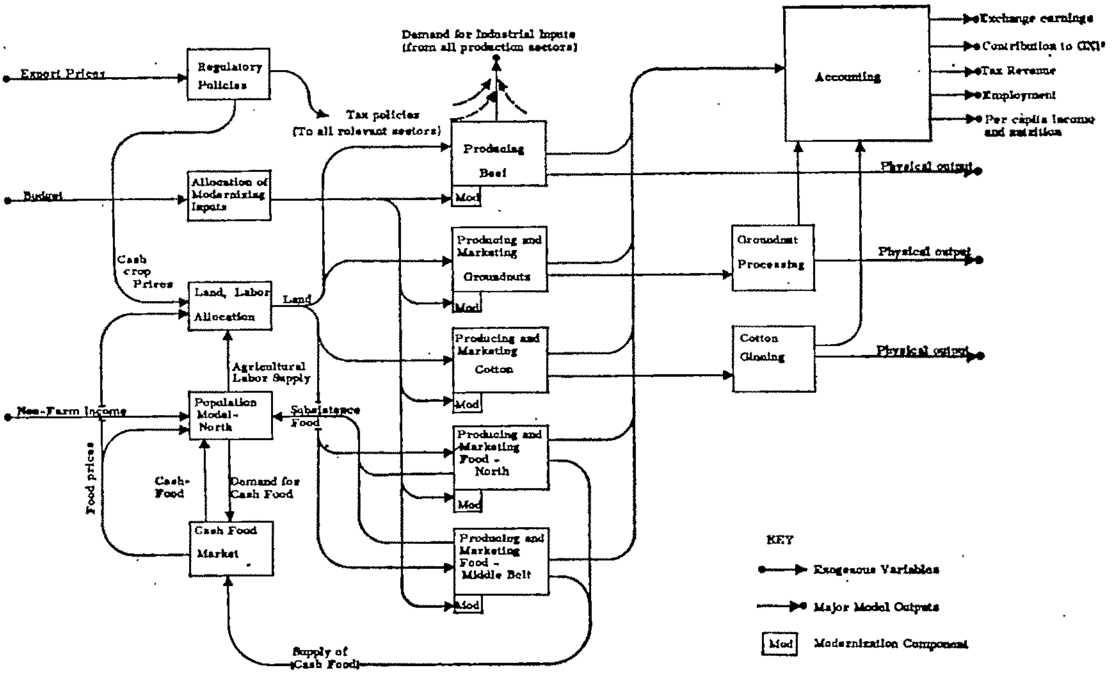


Figure 2. Major sectors and interactions of the northern Nigerian agricultural model

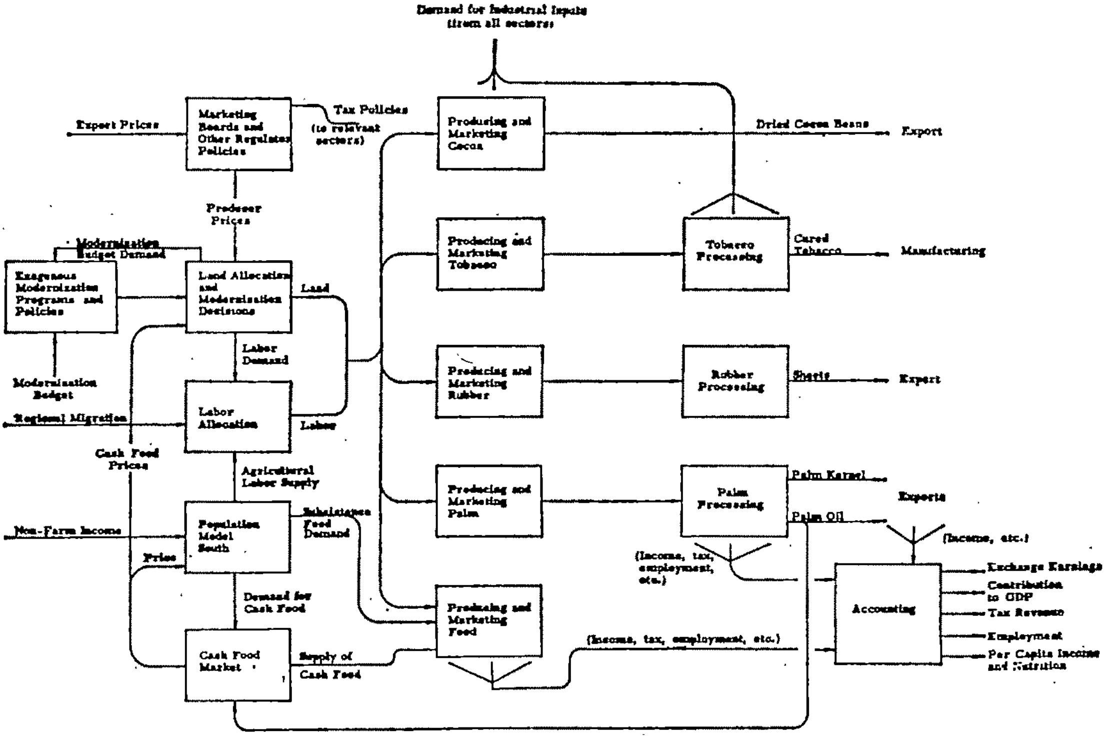
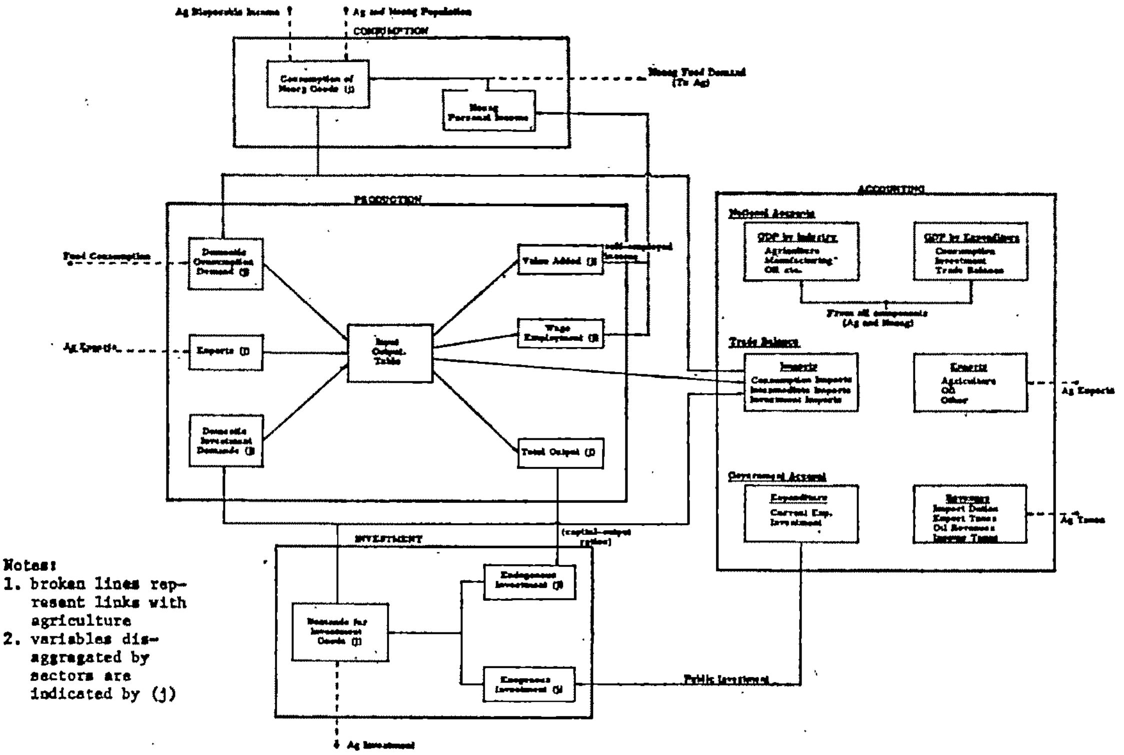

Demand for Industrial Inputs (from all sectors)
Export Prices
Marketing Boards and Other Regulator Policies
Tax Policies (to relevant sectors)
Producer Prices
Modernization Budget Demand
Exogenous Modernization Programs and Policies
Modernization Budget
Land Allocation and Modernization Decisions
Land
Labor Demand
Regional Migration
Labor Allocation
Labor
Cash Food Prices
Agricultural Labor Supply
Non-Farm Income
Population Model South
Subsistence Food Demand
Price
Demand for Cash Food
Cash Food Market
Supply of Cash Food
Producing and Marketing Cocoa
Dried Cocoa Beans
Export
Producing and Marketing Tobacco
Tobacco Processing
Cured Tobacco
Manufacturing
Producing and Marketing Rubber
Rubber Processing
Sheets
Export
Producing and Marketing Palm
Palm Processing
Palm Kernel
Palm Oil
Exports
(Income, tax, employment, etc.)
(Income, etc.)
Producing and Marketing Food
(Income, tax, employment, etc.)
Accounting
Exchange Earnings
Contribution to GDP
Tax Revenue
Employment
Per Capita Income and Nutrition

Figure 3. Major sectors and interactions of the southern Nigerian agricultural model



Notes:
1. broken lines represent links with agriculture
2. variables disaggregated by sectors are indicated by (j)

Figure 4. Model of the nonagricultural economy and the national accounts, Nigeria

where acreages in the various crops partially determine—through competition with grazing land and provision of crop residues—the quantities of TDN available in the cattle component.

Policy inputs to the agricultural submodels include stimulating the modernization of production, reducing or increasing marketing board surpluses (i.e., raising or lowering producer prices), and various forms of taxation. The simulation model then projects the likely consequences of alternative policy options.

Nonagricultural sector submodel

The nonagricultural submodel (Fig. 4) is an aggregated, 10-sector input-output model of the Nigerian economy. Since the primary focus of the national model is on agriculture, the broad, aggregated nonagricultural submodel enables key interactions between agriculture and nonagriculture—agriculture's demands for consumer goods and capital inputs, and nonagriculture's demands for raw materials and food, rural-urban migration—to be investigated [2]. This submodel also constructs the national accounts, including measures of gross national (domestic) product by industry, consumption, investment, government revenues, and import-export balances.

Population component

The population component (Fig. 1) simulates the dynamic growth of a population broken into 27 three-year age cohorts. In addition to computing births, deaths, and aging of the population, the total labor force is determined and split between agricultural and nonagricultural occupations in each region and each ecological zone. Rural and urban food demands as well as rural-urban migration are computed.

Interregional trade component

Submodels are linked in the market and interregional trade component (Fig. 1) where the national food market is modeled. The national model takes cash food supplies from agricultural submodels and food demands from the population component, computes the price of transportation (based on investments in transport capacity) and interregional shipments of food, and determines the market price of food in both regions. In addition, per capita consumption of food by agricultural and nonagricultural populations in each region is calculated.

Model summary

The computer simulation model is a complex of interacting submodels of major elements of the Nigerian economy. It makes possible the investigation of consequences of various agricultural policy options, including interactions with the nonagricultural economy. The total model[1] contains between 2,000 and 3,000 equations and requires about 40 seconds of central processor time on MSU's CDC 6500 computer for a base run (i.e., continuation of present trends and policies) of 42 years of simulated time.

Model Validation

With an extremely large, complex model of a less-developed country, one naturally would expect that estimates of initial conditions and technical and behavioral relationships would necessarily have to be derived via a variety of techniques with data acquired from many different sources. This was the case in the Nigerian model—statistical estimation procedures were used where time series data were available (e.g., income elasticities of demand), previous experimental and survey results were employed (e.g., crop yields, farm product mix, crop acreages), and data gaps were filled with knowledgeable estimates from researchers, extension men, and other informed personnel. These initial estimates were then incorporated into small subcomponents, and computer runs were made for the purpose of detecting errors. Sub-component output was then evaluated using appropriate theory, dynamic systems concepts, and the relationship of the simulated values to historical data and to otherwise expected future values. Where inconsistencies or abnormalities were noted, the problems were diagnosed, changes were made, and testing was continued. Many sensitivity runs were done to test the impact of possible errors in specific model parameters. These often indicated where additional secondary or primary data might be required for more accurate estimation of the sensitive parameters and where structural equations (as data points themselves) needed modification or elaboration. Each sub-component was initially tested individually and then gradually aggregated (in combination with other sub-components) into larger model components whereupon the testing continued (and continues even now). While much of the testing has been rather subjective in nature, some "goodness-of-fit" tests have also been incorporated into the validation process (for more detail, see [3, pp. 279–281] and [6, pp. 34–35, 61–66, 169–172, 256–258]). While the testing procedure cannot conclusively prove that the developed model is a valid representation of how the Nigerian economy will behave in the future, it is felt that the model in its current stage of development is a reasonable approximation which can provide some useful policy comparisons as the validation continues and implementation of the model in Nigerian planning agencies proceeds.

Policy Experimentation

Policy definitions and experimental procedure

Following initial interactions with Nigerian policy makers and researchers, a series of 15 policy experiments was defined and run with the simulation model described above. Initial conditions in the model are for 1953. The model has been "tuned" to approximate observed conditions (e.g., exports) from 1953 to 1970 using observed export and producer prices for that period. The year 1970 was then considered the starting point with (in effect) simulated "initial conditions," and simulation results reported here are analyzed over the period 1970–1995 with policy implementation beginning in 1971. Projections are carried out to 1995 to give long-run diffusion responses to the production campaigns time to exert their major impacts.

With simulation it is easy to build up the complexity of the combinations of policies tested. Starting with runs to evaluate single policies or programs (e.g., reducing marketing board and export taxes), other policies and programs may be successively added, such as alternative production campaigns and infrastructure projects to investigate interactive effects. In addition, a flexible output format allows the researcher either to look at the behavior of aggregated macro-economic variables or to focus upon the investigation of more detailed responses. Policy runs considered here are designed to take advantage of and illustrate these capabilities.

The 15 simulation runs are grouped into four sets that examine increasingly complex interactions at progressively higher levels of industry and geopolitical aggregation. The runs are summarized in Table 1 and described in more detail below. All four sets include Run 1, the base run, as a standard point of reference. The base run projects likely performance under current policies, with no programs to modernize production and with export and marketing board taxes maintained at current levels. Essentially, the base run makes projections assuming no changes in the system as it was in the 1960's.

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[1] While it cannot be completely described here, see [1, 3, and 6] for more detail.

Table 1. Nigerian policy simulation runs

Run No.	Run Definition
1	Base run: Status quo policy—no modernization of production; normal export taxes and marketing board surpluses.
	Policy Run Related to the Cattle Industry
4	Tsetse-fly eradication program, 1971–81.
	Policy Runs Related to Agriculture in the Northern Region
2	Export taxes and marketing board surpluses cut off in 1970.
3	Export taxes and marketing board surpluses phased out from 1970 to 1980.
5	Production campaigns in cotton and groundnuts, 1971–81.
6	Production campaigns in food grains, 1971–81.
7	Production campaigns in cotton, groundnuts and food grains, 1971–81. (Combines Run 5 and Run 6.)
	Policy Runs Related to Agriculture in the Southern Region
2	Export taxes and marketing board surpluses cut off in 1970.
3	Export taxes and marketing board surpluses phased out from 1970 to 1980.
8	Production campaigns in cocoa new planting, cocoa replanting, rubber replanting and palm replanting, 1971–81.
9	Production campaigns in cocoa new planting, cocoa replanting and palm replanting, 1971–81.
10	Production campaigns in cocoa new planting, cocoa replanting, rubber replanting and palm replanting, 1971–81; modernization of palm and rubber processing. (Run 8 plus modernization of palm and rubber processing.)
	Policy Runs Related to Agriculture in Both the Northern and Southern Regions
11	Production campaigns in cotton, groundnuts and food grains in the North, 1971–81; production campaigns in cocoa new planting, cocoa replanting, rubber replanting and palm replanting in the South, 1971–81. (Combines Run 7 and Run 8.)
12	Run 11 plus production campaign in food roots in the Middle Belt, 1971–81.
13	Run 11 with a further improvement in food grain technology after 1980.
14	Run 11 with export taxes and marketing board surpluses cut off in 1970.
15	Run 11 with export taxes and marketing board surpluses phased out from 1971 to 1980.

(For the purposes of these illustrative runs, the civil war in Nigeria was ignored.)

Policies for the cattle industry.—The first set of runs examines one partial solution to some problems currently facing the cattle industry in northern Nigeria. The tsetse fly has a dramatic impact on the area where cattle can graze in good health and on the corresponding size and productivity of the Nigerian cattle industry (and the income accruing to northern Nigerians). In the first set of runs, Run 4 investigates the results of a tsetse fly eradication program budgeted for £3 million over ten years. (An eradication cost of £100/square mile is assumed.)

Policies for the North.—The focus of the second set of runs (Runs 1, 2, 3, 5, 6, and 7) is on interactions among cash crops (cotton and groundnuts) and food crops in the North. Commodity marketing boards in Nigeria have the power to set producer prices as a matter of policy, whereby the boards may generate surpluses for themselves or run at a loss, in effect either taxing or subsidizing the producers. Surpluses may be used for price stabilization purposes or to finance developmental or other projects. These producer prices can have significant impacts on producer incentives and, hence, on commodity outputs and private and public returns. Controversy surrounding the marketing boards in Nigeria center on the issue of whether or not the public sector is a better allocator of resources than the private sector. Runs 2 and 3 compare the effects of cutting off export and marketing board taxes in 1970 or phasing them out over a 10-year period. (These runs reduce taxes in both the North and South.)

In the remaining runs of this set, taxes are maintained at recent levels (25 percent for cotton and groundnuts) while various combinations of production campaigns are tested. Promotion efforts at modernizing agricultural production can generate substantial returns to both the public and private sectors. Such modernization may entail the introduction of higher-yielding biological varieties and/or the encouragement of improved cultural practices such as weeding, spacing, time of planting and application of fertilizers and insecticides. Increase in output can then result in higher incomes for farmers and increased tax revenues and foreign exchange earnings for the public sector. The nonagricultural sector can also experience growth as a result of increased demands from the agricultural sector.

Total budget for the production campaigns is assumed to be £40 million spread over a 10-year period. This budget pays for extension salaries, subsidies, and overhead expenses. Run 5 simulates programs to increase cotton and groundnut production via extension efforts to introduce new seed varieties and improved cultural practices, improving groundnut and cotton yields by 68 percent and 171 percent, respectively. In this run, groundnuts get two thirds of the budget while cotton gets one third. The same end (improved cash crop production) is sought in Run 6 via a food grains modernization program (hopefully to release land for cash crop expansion). If food production is modernized, the model provides for cotton yields to increase as the labor pressure is eased; this reflects cotton planted earlier in the season. New technologies in food grain production are assumed to increase yield two and one-half times. Here, all £40 million go to food grain programs. All three programs—cotton, groundnut, and food grains—are then combined in Run 7, where the budget is split 40 percent, 20 percent, and 40 percent to groundnuts, cotton, and food, respectively.

Policies for the South.—Agricultural policies and programs aimed at the southern ecological region are examined in simulation Runs 2, 3, 8, 9, and 10. Runs 2 and 3 again compare the consequences of cutting off export and marketing board taxes or, alternatively, phasing them out (in both regions). Normal levels of marketing board taxes are assumed to be 20 percent for the three commodities handled by marketing boards (cocoa, palm oil, and palm kernels), while export taxes for those three and rubber are 20 percent, 15 percent, 15 percent, and 15 percent, respectively.

Runs 8, 9, and 10 investigate production campaigns in the perennial crops and efforts to improve processing methods for oil palm and rubber products. The production campaigns assume a budget of £40 million over 10 years to pay for extension salaries, subsidies, and overhead expenses. Run 8 involves a modest new planting cocoa program and replanting programs for cocoa, palm, and rubber, with the budget split among these programs 10 percent, 30 percent, 40 percent, and 20 percent, respectively. Of the 40 percent in the palm replanting program, 25 percent is used in the areas where palm competes with rubber, and 75 percent is applied to areas where palm has no perennial competitors. Run 9 attempts to highlight the interactive effects of the oil palm-rubber competition (in comparison with Run 8) by not conducting the rubber replanting program and devoting that portion of the budget to palm replanting. Assumed yields at maturity for new planted cocoa and replanted cocoa, palm, and rubber represent improvements of 86 percent, 47 percent, 49 percent, and 150 percent, respectively. The model provides for these yields to increase gradually another 20 percent as farmers gain experience with new methods of cultivation involved in modern production.

Finally, Run 10 adds investment in modern processing facilities for oil palm and rubber products to the programs in Run 8. For palm this means Stork hydraulic presses, while for rubber it means crumb factories. The investment rate is established at £100 thousand and £200 thousand per year for palm and rubber, respectively, until a prespecified level of transformation has been reached (50 percent for palm and 100 percent for rubber). While rubber processing is being transformed from sheets to crumb, the model also simulates a gradual increase in the domestic industrial demand for crumb rubber up to 50 percent of production.

Policies for both regions.—Whereas the first three sets of runs focus on industry- or region-specific policies, the fourth set, Runs 11, 12, 13, 14, and 15, examines aggregate and interactive effects of agricultural development policies and programs in both the North and South. Run 11 combines Runs 7 and 8 so that the following production campaigns are carried out simultaneously at the same budget levels (£40 million in each the North and the South) and in the same commodity proportions as specified above: modernization of cotton, groundnuts, and food grains in the North, and new planting of cocoa and replanting of cocoa, palm, and rubber in the South.

Run 12 investigates the impact of modernizing food production (roots and tubers) in the Middle Belt area of the North in addition to the modernization programs discussed above. Thus the implications for regional specialization, i.e., the South's specialization in perennials and the North's in food, can be specifically investigated. This run is conditional in that modernization of root and tuber food production is dependent upon future development of the requisite technologies.

Run 13 is also conditional. With the programs specified in Run 11, a further doubling of food grains yields is assumed to diffuse over a period of four or five years after 1980 as a result of new technologies that may be developed in the next ten years by national and international research stations. Thus, modern food yields after 1980 are assumed to be potentially five times the current traditional yields experienced in northern Nigeria. This experiment investigates the potential effects on exports (due to cash crop interactions), food prices, and consumption.

Finally, Runs 14 and 15 combine the production campaigns of Run 11 with the export and marketing board tax policies of Runs 2 and 3, respectively, i.e., the alternatives of cutting off and phasing out these taxes. Results of all 15 runs are analyzed and graphically portrayed in the following sections.

Analysis of simulated results

Policies related to the cattle industry.—Run 4 simulates a 10-year tsetse fly eradication program budget at £3 million. This analysis does not consider other livestock programs or their potential interactions with other agricultural policies and programs due to limitations of the current model.[2]

Animal populations,[3] sales, and resultant incomes all rise as might be expected. Acreage of fly-free grazing land increases dramatically, and general range condition[4] improves substantially over the base run as the grazing pressure is reduced.

In every case, however, the gains attributed to the fly eradication program in Run 4 are temporary in the sense that these performance variables, after an initial increase, return to the same *trends* as experienced in the base run, although at a higher *level*. By 1995 the slopes of the results of Run 4 are all either the same as the slopes of Run 1 results or are approaching these. The animal population (Fig. 5) increases rapidly as new grazing areas are opened. Once these new areas have reached their animal capacity, however, male and female populations grow at the same rate as in the base run, causing sales and incomes to undergo the same growth rates as in Run 1 after the initial spurt.

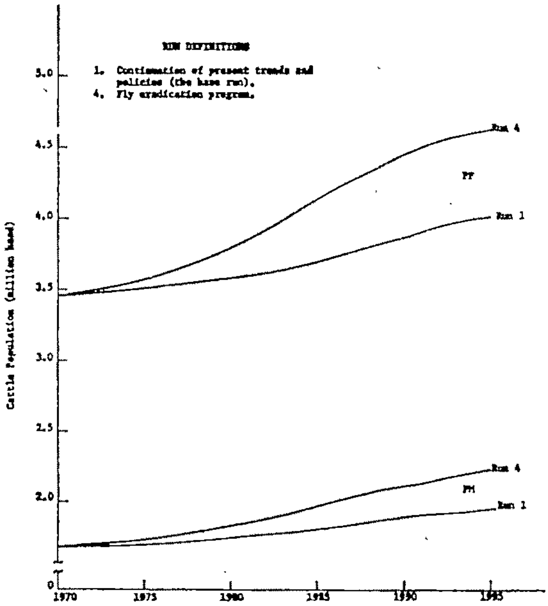

Figure 5. Cattle population of males (PM) and females (PF), 1970–1995, with and without a fly eradication program

The amount of fly-free grazing land experiences a dramatic increase from 1975 to 1985 as a direct result of the eradication program (Fig. 6). After 1985, however, grazing land declines at the same rate as in Run 1 due to growth in the human population and corresponding expansion of crop lands. Similarly, the decline in range condition due to overgrazing is slowed substantially as new areas are opened and grazing pressure eases. But the cattle population is grazing even these new areas to capacity by 1995, and the range condition continues to decline at the same rate as in the base run.

The conclusion to be drawn from this is that the fly eradication program has merely "bought time." Deterioration of overgrazed ranges has been delayed but not halted (much less reversed). Loss of grazing land to crops continues in Run 4 at the same rate as in Run 1. The animal population growth rate (and, hence, the growth in beef and milk supplies) is the same after the eradication program as before.

This is not to say there should not be a fly eradication program. The program does have substantial short-run results, and the time

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[2] Kellogg's study [5] examines additional considerations on mortality loss and marketing costs, etc., which could be incorporated into the model for a more comprehensive analysis of this program and others related to the cattle industry.

[3] The initial (1970) cattle population assumed in the model is about five million head (Fig. 5). Although this figure is below current estimates of Nigeria's cattle herds, the *relative* results of Runs 1 and 4 are still valid.

[4] "Range condition" is defined as an index of range land grass yields and reflects the carrying capacity of the range. Its value at any time during the simulation period (1970–1995) is the ratio of grass yields at that time to grass yields at the initial time (1970).

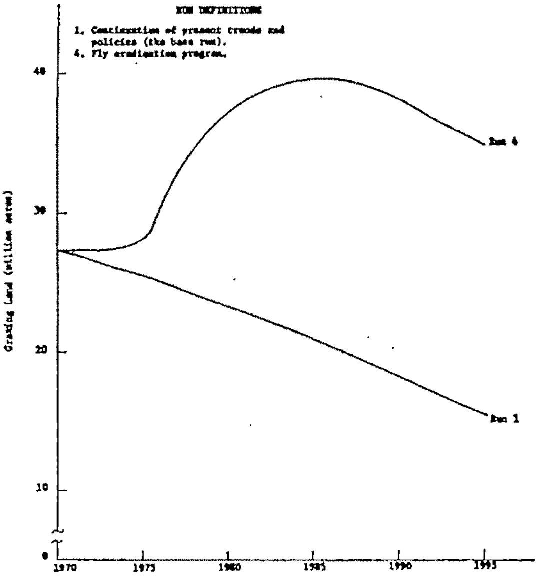

Figure 6. Fly-free grazing land, 1970–1995, with and without a fly eradication program

gained by it could be used to carry out programs that will have more long-lasting results. Indeed, other programs, such as grazing reserves, might not even be feasible without prior elimination of the tsetse fly and consequent reduction in grazing pressure in the potential grazing reserve areas.

Northern regional policies.—Consequences of policies and programs relevant to northern Nigeria are investigated in Runs 1, 2, 3, 5, 6, and 7 as defined above and in Table 1.

As expected, the elimination of marketing board and export taxes stimulates agricultural production and incomes. Value added in agriculture increases slightly over the base run (Fig. 7), as do exports (Fig. 8).[5] Immediate elimination of taxes (Run 2) initially causes higher exports and value added than Run 3 (phasing out taxes), but also a slightly higher food price (not shown) for the nonagricultural population. Disposable agricultural worker incomes (Fig. 9)[6] markedly increased over the base run due partly to the higher producer prices for cash crops and to slightly higher food prices.[7]

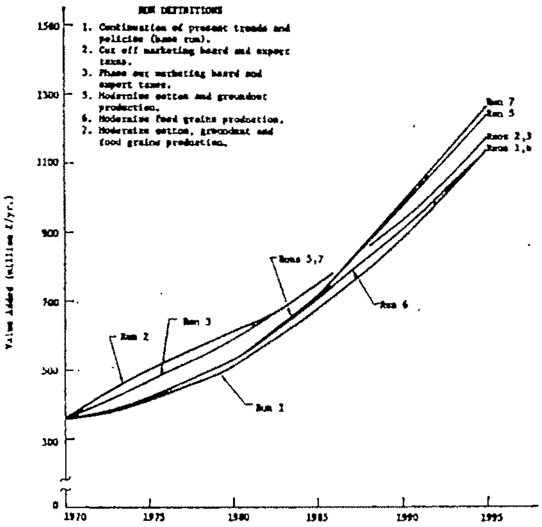

Figure 7. Total value added in agriculture in the North, 1970–1995, under various policy conditions

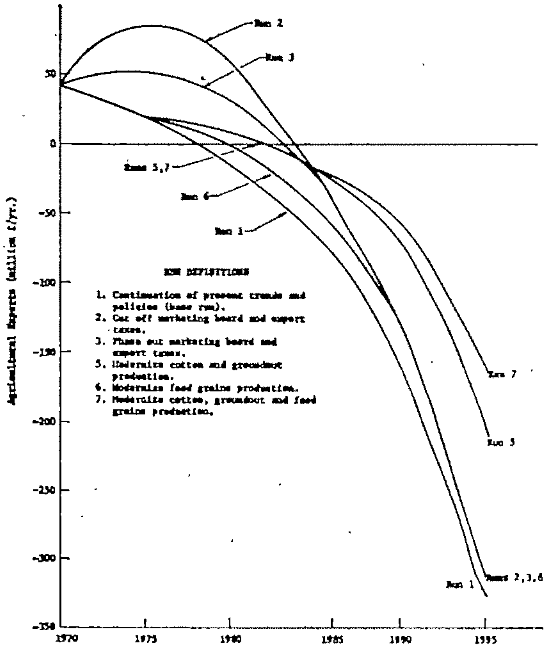

Figure 8. Foreign exchange from northern agricultural exports (including imports of cotton and beef), 1970–1995, under various policy conditions

The major contributor to increased incomes,

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[5] The large negative foreign exchange shown in Figure 8 is due primarily to projected import demands of the textile industry being charged to cotton exports. In addition, beef for consumption forms about 10–20 percent of the indicated imports.

[6] Disposable income in Figure 9 (and Fig. 13) includes wages earned but is net of agricultural sector debt service and interest.

[7] Food accounts for about 90 percent of agricultural value added in the North.

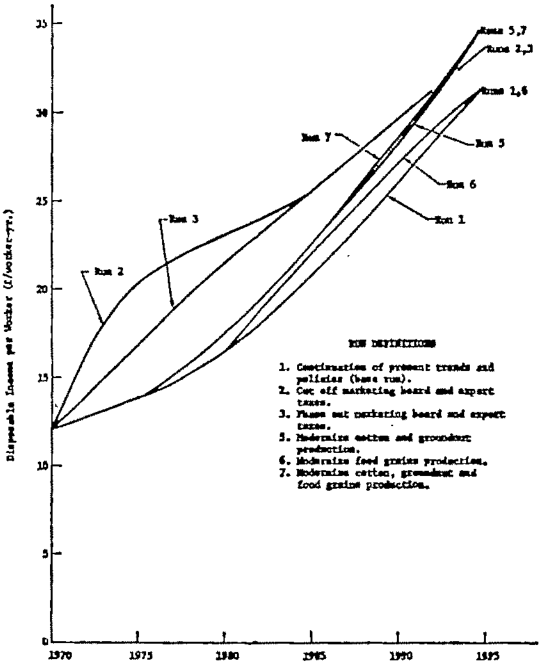

Figure 9. Disposable income per agricultural worker in the North, 1970–1995, under various policy conditions

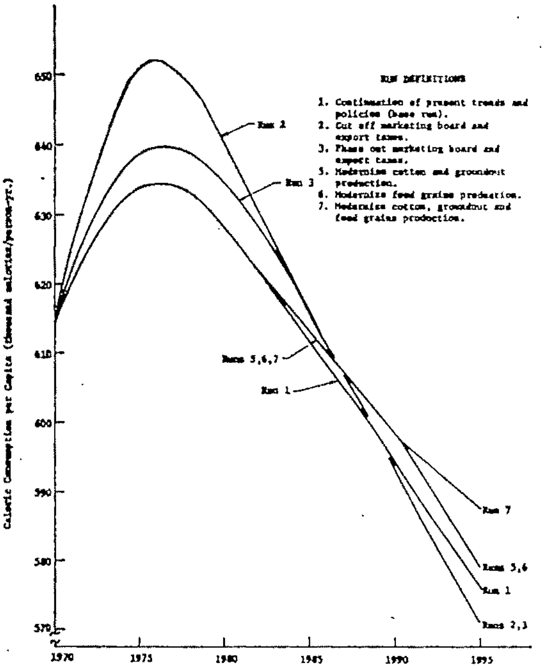

Figure 10. Caloric consumption (of staples) per capita of the northern nonagricultural population, 1970–1995, under various policy conditions

however, is the greatly increased (relative to the base run) cash food sales to the South (not shown) to meet higher agricultural and nonagricultural demands for food. Southern agricultural *cash* food demands increase as the agricultural sector reduces its desired level of *subsistence* in response to higher cash incomes resulting from the export crop tax reductions.[8] In addition, southern nonagricultural food demands rise due to the rise in nonagricultural income resulting from greater demands for nonagricultural goods and services generated by increased agricultural income (i.e., multiplier effects).

Long run results of Run 2 are similar to those of Run 3. After 1980, when marketing board and export taxes are zero in either policy situation, food consumption by the nonagricultural population (Fig. 10) shows a substantial rise as the increased agricultural incomes from Runs 2 and 3 begin to have their multiplier effects on nonagricultural incomes. Later, higher food prices cause nonagricultural food consumption to approach the same level as in the base run.

Figure 10 indicates steadily falling nonagricultural food consumption in all runs (as does Fig. 14). These results must be interpreted with caution. They represent only staple grain and root crop consumption and do not incorporate other sources of nutrition such as fish, meat, fruits, and vegetables.

Modernization of cotton and groundnut production (Run 5) substantially improves the performance of all the variables observed compared to both the base run and the runs eliminating taxes. Foreign exchange increases the most (Fig. 8), about 30 percent over Run 1. Since food crops rather than export crops dominate northern agricultural production, other variables such as value added (Fig. 7), income (Fig. 9) and, hence, food consumption (Fig. 10) show a less dramatic increase. Marketing board revenues show a 150 percent increase by 1995.

Run 6 examines a program to modernize food grains production. Indeed, foreign exchange and marketing board revenues do pick up (over the base run) as land and labor are released for cash crop production. The difference is less pronounced at the end of the run (1995) than earlier in the simulated time period as the initial reduction in total food land is gradually reversed to meet the subsistence demands of the expanding agricultural population. Throughout the time period 1970–1995, exports and marketing board revenues in Run 6 are below those of Run 5 in which policies are targeted directly to the transformation of cash crop production. This can be explained by the slower diffusion of food modernization (compared to cash crop modernization diffusion) built into the model. A larger promotional effort (budget) would stimulate a quicker response to food modernization and thus a larger effect on cash crop production.

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[8] Runs 2 and 3 reduce taxes in *both* regions.

In Run 7 promotional efforts are conducted in cotton, groundnuts, *and* food grains simultaneously. Run 7 results are more than the mere addition of output variable increases experienced in Runs 5 and 6. Marketing board revenues provide a striking example of this. Run 7 revenues in 1995 are 200 percent greater than Run 1 while revenues in Runs 5 and 6 are 150 percent and 15 percent greater, respectively, because cash crop production, expanded onto former food land as a consequence of food modernization, is itself modernized in Run 7 and further augments the positive results of Run 6. More significantly in the long run, modernization of food in conjunction with that of cotton and groundnuts allows more timely planting of the cash crops, resulting in even higher yields for the modern varieties than would otherwise be obtained.

Food prices are lower in Run 7 than in any other run. This effect is more than offset, however, by the increased productivity of food, so that value added and income are slightly higher in Run 7 than in Run 5. Lower food prices coupled with increased nonagricultural income result in higher nonagricultural food consumption (Fig. 10).

Southern regional policies.—The set of runs which investigates the consequences of policies and programs relevant to southern Nigeria includes Runs 1, 2, 3, 8, 9, and 10 as defined earlier and in Table 1.

The most striking observation about Runs 2 and 3 (cutting off and phasing out taxes) is not that the long run results are virtually identical, for taxes are eventually zero in both cases. Nor is it that incomes, value added, and exports are initially higher than the other runs and consistently higher than the base run, for the reduction in taxes represents an immediate increase in producer prices, whereas a delay is involved for the perennial modernization programs to show results.[9] The most striking observation concerning the behavior shown in Runs 2 and 3 is that value added, exports, and income (Figs. 11, 12 and 13) are relatively higher *initially* in Run 2 than in Run 3, while *later* in the simulated time period (after about 1978), they are relatively higher in Run 3 than in Run 2, finally approaching the same steady state levels in both runs. Run 2 should indeed have higher results initially, since producer price increases are immediate. Short term supply (harvest) response is initially sharp and then tapers off, returning ultimately to normal levels as farmers gradually come to regard the higher prices as "normal." Exports begin to increase again after 1980 (Fig. 12) as the long term supply (planting) response to higher prices becomes increasingly dominant, finally tapering off again as acreage expands to its limit (as in the base run) and production declines from aging traditional trees.

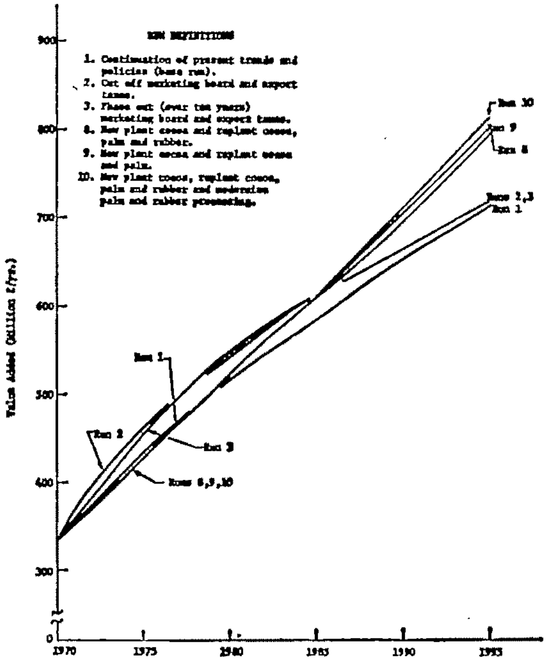

Figure 11. Total value added in agriculture in the South, 1970–1995, under various policy conditions

In Run 3 prices rise steadily over a 10-year period while taxes are being phased out. Thus the harvest response is lower than in Run 2, although it lasts longer since the new price

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[9] This delay is due to the natural gestation and maturation lags of the perennials and the longer lags before the innovations are diffused beyond the direct promotion results.

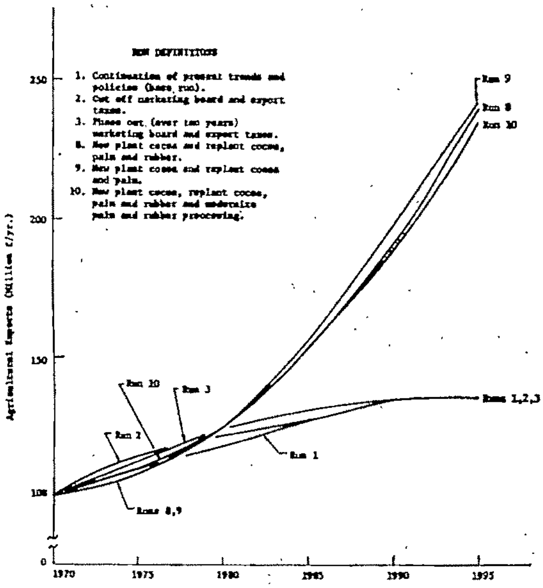

Figure 12. Foreign exchange from southern agricultural exports, 1970–1995, under various policy conditions

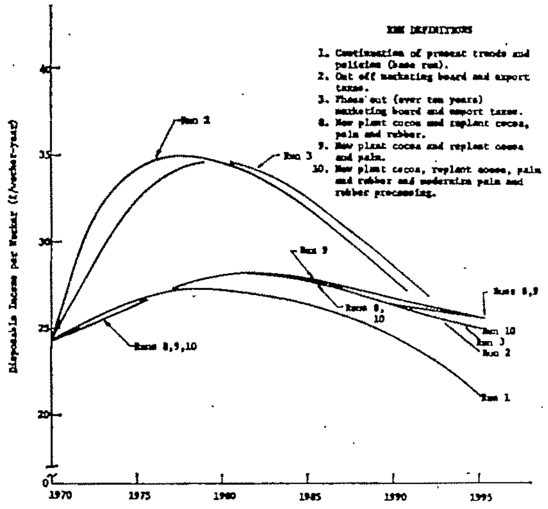

Figure 13. Real disposable income per agricultural worker in the South, 1970–1995, under various policy conditions

(achieved when taxes have finally been eliminated) is not seen as "normal" by the farmers until later. Therefore, while exports in Run 2 taper off, the harvest and planting responses reinforce each other in Run 3. Eventually acreage limits are reached, the natural aging process decreases yields, and long run results of Runs 2 and 3 are virtually the same (Figs. 11, 12 and 13).

Although long run exports with taxes removed are virtually the same as in the base run due to capacity limits and aging traditional trees, higher prices keep value added and income per worker (Figs. 11 and 13) higher than in the base run. Per worker income falls during the latter part of the runs because the labor force is growing faster than income.

Increased agricultural incomes, via multiplier effects on nonagricultural incomes, cause a higher consumption (in Runs 2 and 3 than in Run 1) of staple calories by the nonagricultural population through most of the simulated time period (Fig. 14). As incomes stabilize in the long run, however, the higher food prices associated with Runs 2 and 3 result in lower nonagricultural staple food consumption.

Comparison of Runs 8 and 10 (production campaigns in the three major perennial commodities without and with modernization of palm and rubber processing) leads to some interesting observations. Value added (Fig. 11) and marketing board revenues (not shown) are higher in Run 10 than in Run 8 due to increased technical efficiency of oil palm and rubber processing facilities. While palm oil exports are also substantially improved, total exports (Fig. 12) are lower due to the assumption in Run 10

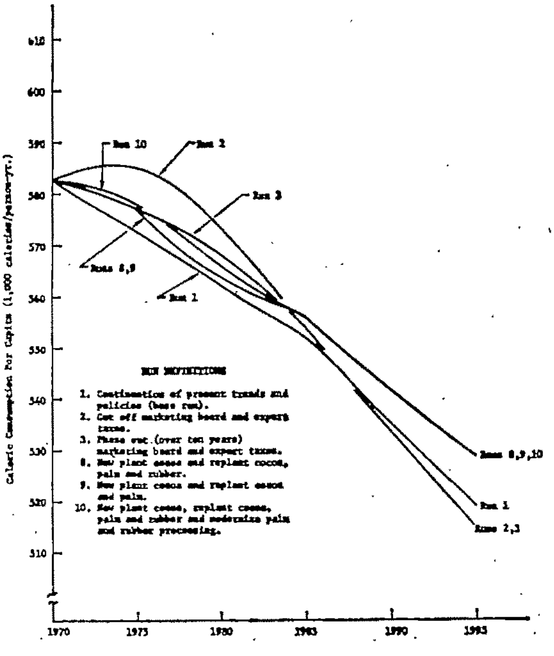

Figure 14. Caloric consumption (of staples) per capita of the southern nonagricultural population, 1970–1995, under various policy conditions

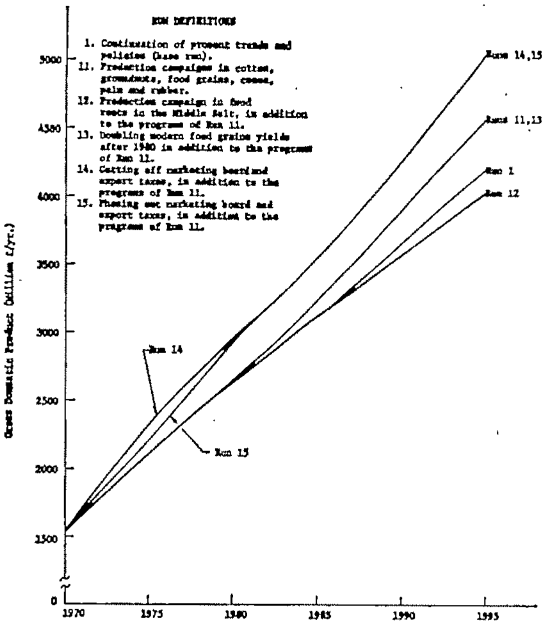

Figure 15. Gross domestic product (assuming marketing board and export taxes are not put to productive use), 1970–1995, under various policy conditions

that the domestic demand for rubber increases to 50 percent of production over a 15-year period, reducing rubber exports (which do not pass through a marketing board and thus do not diminish marketing board revenues). Indeed, exports *are* initially higher in Run 10 while domestic rubber demand is still low.

In spite of this increased production, incomes in Run 10 are *lower* by 1990 than in Run 8 (Fig. 13) because palm oil processing with the Stork hydraulic presses, while *technically* more efficient (i.e., more oil is extracted per pound of fruit), is *economically* inefficient. That is, increased processing costs outweigh revenue from increased production, making palm processing unprofitable.[10] The centralized crumb rubber factories, on the other hand, prove to be economically as well as technically more efficient than the traditional sheet-making facilities operated at the village level.

Run 9 was an experiment to investigate the consequences of increasing the palm replanting effort at the expense of rubber in the crop sector where the two perennials compete. Indeed, palm oil exports (not shown) do improve substantially over Run 8. Value added and total exports are also higher in spite of the still traditional rubber production.

It is interesting to note that value added, exports, marketing board revenues, and income per worker are all lower in Runs 8 and 9 than in the base run for about the first six to eight years of the simulated time period (1976–1978) before rising to substantially improved levels. This is because replanting programs mean removing trees from production, and a gestation lag occurs before new trees come into production.

Nonagricultural food consumption is higher in Runs 8, 9, and 10 than in the other runs (Fig 14) due to the multiplier effects of increased agricultural incomes (Fig. 13) on nonagricultural incomes and to slightly lower food prices

National Policies.—The fourth set of runs Runs 1, 11, 12, 13, 14, and 15, examines the results of some national agricultural development policies and programs. Coupled with modernization programs, the elimination of marketing board and export taxes (Runs 14 and 15) substantially enhances the results obtained when the modernization programs are implemented in the presence of these taxes Figure 16 indicates that, while both total ex·

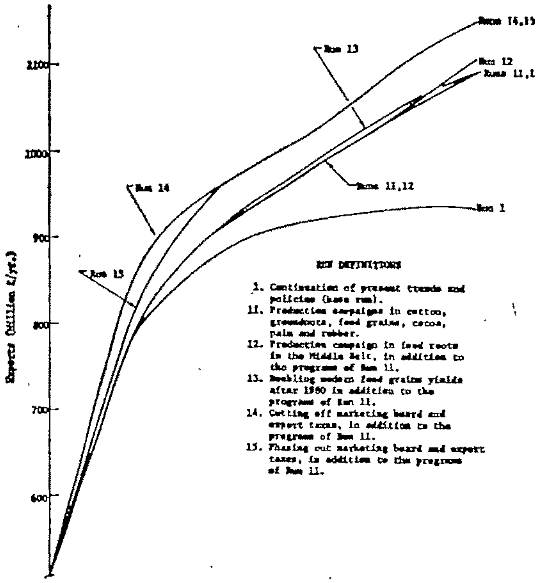

Figure 16. Total exports (agricultural and nonagricultural), 1970–1995, under various policy conditions

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[10] Transformation of processing takes place in the model irregardless of its profitability and is carried out solely by an exogenous (policy) investment. The model's rudimentary processing component would have to be expanded to simulate investment decisions more realistically.

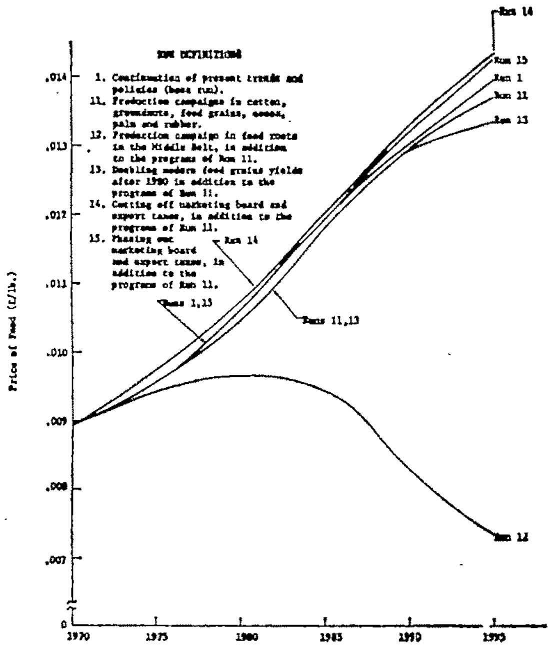

Figure 17. Market price of food in the North, 1970–1995, under various policy conditions

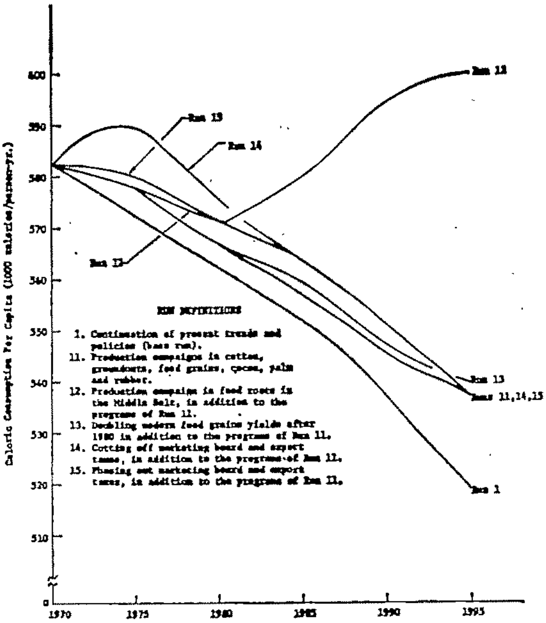

Figure 18. Caloric consumption (of staples) of the southern nonagricultural population, 1970–1995, under various policy conditions

ports and total imports (not shown) increase in Runs 14 and 15 compared to Run 11, exports experience a relatively greater rise, leaving Nigeria with a more favorable balance of payments. Similar increases are seen in other variables, such as GDP (gross domestic product, assuming marketing board and export tax revenues are not put to productive use) (Fig. 15), value added in agriculture, and agricultural exports.

Nonagricultural food consumption is higher in Runs 11, 14, and 15 (with modernization) than in the base run (Fig. 18). This is due to the multiplier effect of increased agricultural income on nonagricultural income, i.e., increasing agricultural demand for consumer goods from the nonagricultural sector.

Run 12 was an attempt to project the consequences of increased production of food root crops in the Middle Belt (assuming the requisite improved technology to be available). Indications are that the South would tend to specialize in exports while importing food from the North. By 1995 food shipments (not shown) increase by about 56 percent over Run 11. However, this increase results in much lower food prices (Fig. 17) rather than the substitution of perennial production for food production; southern agricultural exports remain virtually the same as in Run 11. This can be attributed to the current limitations of the southern submodel, specifically the constraint on the transfer of food land to perennial production [1, Ch. 3]. Without this restriction, a move to export specialization in the South would be expected in the presence of a secure food supply from the North. Lower food prices do lead to a dramatically higher level of food consumption by the nonagricultural population (Fig. 18).

An interesting observation can be made concerning agricultural value added (not shown) and gross domestic product (GDP) (Fig. 15). Such a large proportion of value added and GDP is derived from food production (about 80 percent for agricultural value added and 30 percent for GDP) that these variables at current prices are depressed in Run 11 and particularly in Run 12 due to lower food prices (Fig. 17). In "real" terms (i.e., relative to food prices in the base run), Runs 11 and 12 would show even greater improvements over Run 1, with Run 12 probably taking the lead.

Modern food grain yields in the North were gradually doubled in Run 13 over a four to five-year period after 1980 (to five times the current traditional yields) to investigate the consequences of the introduction and diffusion of new technologies expected to be developed during the 1970's. Results show that exports in the North do improve substantially over Run 11 after 1980. Value added also increases slightly. However, by the end of the simulated time period, the results of Run 13 and Run 11 become similar. The initial increase in cash crop acreage, resulting from labor and land freed from subsistence food production, is later reduced as the population continues to expand and more food land is required. Value added in Run 13 eventually falls below that in Run 11 because of the somewhat lower food prices. The effect on southern exports is nil, while the lower food prices cause southern value added to fall slightly and nonagricultural food consumption to rise.

Value added in the North rises more than twice as fast as in the South due to the much more dominant role food plays in northern agriculture. Since food accounts for over 90 percent of value added in the North and only about 75 percent in the South (in the base run), rising food prices and steady or falling export prices result in a more rapid rise in value added in the North compared to the South.

Policy conclusions

The major conclusion to be drawn from the policy simulation results is that a technological transformation of agricultural export crop production is necessary for sustained economic growth.[11] Other development policies show short-run benefits which are eventually eaten up by continued population growth, by activated land constraints, and by declining yields of aging perennials. This was true of the tsetse fly eradication program in which initial gains were later lost to a growing cattle population and expanding crop acreages. It was true of the elimination of marketing board and export taxes, where land constraints and declining yields in the South and an expanding national population eventually nullified positive results of the higher producer prices. It was also true of the food grains modernization programs in the North, where the growing population eventually reversed the gains made in the increased availability of land and labor for export crop production. Only production campaigns to modernize the production of export crops (via the introduction of high-yielding seed varieties and improved cultural practices) had beneficial consequences which were maintained in the long run. In addition, the combination of export crop modernization programs with the reduction of market board and export taxes showed even more pronounced long-run benefits due to the complementarity of these policies.

Other conclusions can be made concerning interregional and intersectoral interactions North-South shipments of food do play a substantial role in feeding the southern population and indications are that there is a potential for regional specialization: in the northern Middle Belt area, where roots and tubers (the primary components of southern staple consumption) can be grown, food would be provided for a South which would specialize in export perennial crop production.

Interactions between the nonagricultural and agricultural sectors are strong and indicate that agricultural development can also lead to growth in the nonagricultural sector. For example, rising agricultural incomes mean an increasing demand for nonagricultural consumer and investment goods, creating more employment and higher incomes in the nonagricultural sector. This in turn means greater nonagricultural demands for agricultural products (food and raw materials), a further spur to agricultural income.[12]

Conclusions

It seems appropriate to try to draw conclusions concerning the stage of development the team has reached in constructing generalized system simulation models. It is felt that the model and many of its components are ready for application. This is not to state that they are complete. However, they are ready for application in the sense that application should always be expected to involve extensive field work and interaction with decision makers which will reveal needed modification and further developments of the models. This will be true whether the models summarized above are applied in Nigeria or in some other country.

It is the team's conviction that the building blocks or components of these models are potentially useful in a wide variety of countrie and situations. The Nigerian components of the model can be taken apart and reused to simulate and analyze other entire agricultural sectors. The nonagricultural component itself will be generally useful in relating the agricultural economies of various countries to their nonagricultural economies. In addition to being useful in constructing models of the entire agricultural economy of different countries, components developed for the total model are potentially useful in designing, analyzing, and evaluating programs and more detailed projects at the subsector level. For example, the perennial crop components designed to model the Nigerian cocoa, rubber, and palm subsectors have widespread applicability in modeling corresponding subsectors of other countries. These perennial crop components also have potential applications in the developed world—possibly in modeling the vineyards of California, France, and Chile, and the cherry orchards of Michigan. Demographic components used for modeling the Nigerian beef herd may also be used, for example, to model the cow and buffalo herds of India as well as the cattle population of the United States.

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[11] This conclusion is, of course, dependent on the current model's validity and is limited to the policies and programs tested. It is not inconceivable that there may be some other route to sustained growth than the one indicated here.

[12] See [2] for a fuller discussion of this multiplier effect and other agriculture-nonagriculture interactions.

In short, although the components developed are generally applicable in various subsectors of the agricultural sector of many countries, such applications will inevitably involve much field work and much interaction with decision makers to make the generalized components relevant to specific applications and to find the appropriate data. In this way, components from the Nigerian model have been adapted and successfully applied in Venezuela, Colombia, and Korea [7].

It also appears that the processes which have been modeled are so important to the countries and their decision makers that expatriate advisors themselves are inherently incapable of fully developing and applying the models. While there are areas in which applications can be made by expatriate advisors and staff members, it must be recognized that full use of these models by a particular LDC requires their mastery by indigenous personnel. In order for the Nigerian model to be fully used in Nigeria, for example, it will have to be mastered by Nigerians and applied, further developed, modified, and extended by Nigerian investigators in closer interaction with Nigerian decision makers than can or should be carried out by foreign advisors.

Finally, the policy decision maker, in evaluating simulated results, must be aware of the assumptions and simplifications built into the model, and he must appreciate limitations that exist *vis-à-vis* the questions the model is capable of addressing. In particular, the model is principally an economic model which will indicate the likely *economic* consequences of alternative policies; it was not designed to answer *social* or *political* questions directly. The policy-making process must still be responsive to political pressures and social interests which are indispensable components of that same process. In short, a simulation model, while potentially an integral and important part of the decision-making process, will not replace the decision maker; but it will give him more information, help to identify new and economically feasible policy options, and sharpen his intuition, thus making for better decisions.

References

[1] ABKIN, MICHAEL H., "Policy Making for Economic Development: A System Simulation Model of the Agricultural Economy of Southern Nigeria," unpublished Ph.D. thesis, Michigan State University, 1972.

[2] BYERLEE, DEREK R., "Agricultural Development and Urban Unemployment: A Simulation Analysis of the Nigerian Economy," unpublished Ph.D. thesis, Oregon State University, 1971.

[3] HALTER, A. N., M. L. HAYENGA, AND T. J. MANETSCH, "Simulating a Developing Agricultural Economy: Methodology and Planning Capability," *Am. J. Agr. Econ.* 52:272–284, May 1970.

[4] HAYENGA, M. L., T. J. MANETSCH, AND A. N. HALTER, "Computer Simulation as a Planning Tool in Developing Economies," *Am. J. Agr. Econ.* 50:1755–1759, Dec. 1968.

[5] KELLOGG, EARL D., "A Temporal and Spatial Model to Assist in Evaluating Investments in the Nigerian Beef Distribution System," unpublished Ph.D. thesis, Michigan State University, 1971.

[6] MANETSCH, T. J., *et al.*, *A Generalized Simulation Approach to Agricultural Sector Analysis with Special Reference to Nigeria*, final report to USAID, Michigan State University, E. Lansing, Nov. 1971.

[7] ROSSMILLER, G. E., *et al.*, *Korean Agricultural Sector Analysis and Recommended Development Strategies, 1971–1985*, report to USAID, Michigan State University, 1972.

Systems-Simulation in a Practical Policy-Making Setting: The Venezuelan Cattle Industry

S. F. MILLER AND A. N. HALTER

Shifting the Venezuelan cattle industry from traditional to modern production is the problem of formulating policy at the federal government level. A systems-simulation model shows the consequences, through time, of the current set of policies and hypothesizes the consequences of other policy alternatives. Validity of the model was established, on the basis of the decision-maker's criterion, through a game of hide-and-go-seek. Interaction between the researchers and decision-makers brought together the relevant positive and normative information before a policy was established.

SIMULATION modeling has been proposed as a useful tool in policy formulation in underdeveloped countries [6]. Claims are made concerning its possible implementation in a policy-making environment, but little experience has been reported on actual cases of implementation. This paper reports on the implementation of a component of a larger simulation model within an agency of an underdeveloped country. In contrast to the Nigerian model [6], the intent of which was to develop system components without necessarily applying them, the effort reported here was a cooperative endeavor of three government agencies at the policy-making and/or planning level to use the cattle component of the Nigerian model to test alternative policies and programs directed toward development of the cattle industry of Venezuela.

The systems-simulation approach is a flexible, iterative problem-investigating process that includes problem formulation, mathematical modeling, simulation testing and refinement of the model, and problem solution in close consultation with decision-makers [4]. The process places emphasis upon creative design of alternative courses of action to help provide solutions to development problems at policy, program, and project levels. The process starts with problem definition and ends with problem solution, but these as well as the intermediate steps can, and no doubt will, be repeated in an iterative fashion. The process is learning in nature, and prior steps are often repeated on the basis of information acquired during a subsequent step; hence the process explicitly recognizes the feedback character of the problem investigation procedure.

A system is a collection of component parts that interact in such a way as to behave as a whole entity with a purpose. Real world systems have such purposes as generating individual and group income, social justice, tax revenues, food, nutrients, and political power. Mathematical models are abstractions of real world systems brought about through the use of subject matter theory. The relation between the variables and interactions of a real world system and a mathematical model is always many to few. A simulation model is the analogue of the mathematical model in that its function is the same, but its structure and origin may be different. Numerical methods are used to convert the mathematical model to a computer model. The output of a simulation in the context here is a set of system performance variables associated with a set of policies and/or development strategies indicating the attainment of various purposes (benefits) and the incurrence of various damages (costs) at different points in time from alternative policies, programs, and projects. These estimates can be compared through interaction with policy makers for different alternatives in choosing the alternative which best solves the problem under consideration.

This paper follows the steps of the systems-simulation approach. Because the process is ideally carried on in an environment which includes decision makers and policy-setters, certain background and details of the interaction between the researchers and decision-makers are essential to understanding the import of the application. Interaction sessions were necessary to bring together the positive and normative information required to define the problem, to specify the objectives of the policies and programs, and to enumerate policies

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and programs to be simulated by the model. In this paper what may sometimes seem like "biographical information," "salesmanship," and "a presentation to a group of Venezuelan policy makers" (comments of reviewers) is essentially the reporting of actual events. This is not an academic exercise, but the reporting of "real life" details of the application of the systems-simulation approach in a practical policy-making setting.

Problem Definition

The presence of Dr. Miller in Venezuela for approximately nine months before the simulation modeling began provided an opportunity for him to become familiar with the problems of the Venezuelan cattle industry. After the decision was made in August 1971 to attempt to apply the Nigerian cattle component [6] to Venezuela, numerous meetings and seminars were held with personnel from a variety of official governmental organizations. In addition, the work of the Livestock Productivity Project, which had been in existence for three years, was of much help in identifying the problem toward which the simulation effort was to be oriented.

Present cattle production in Venezuela is characterized by low extraction rates, low calving rates, high death rates, lack of dry season nutrition, low milk production per cow, general overstocking of range lands, deteriorating real producer prices, and rising input costs. It continues to function in many parts of the country more as an extractive enterprise than a productive one. Cattle are raised with the minimum of care and concern.

The cattle population was estimated to be 7,000,000 in 1968 by the Food and Agriculture Organization of the United Nations (FAO) and the Organization of American States (OAS) [9]. From the national herd in the same year it was estimated that 748,000 animals were slaughtered. This implies an off-take or extraction rate of 10.7 percent, which compares unfavorably with other countries. For example, the extraction rate in the United States was 37 percent in 1969. Similarly, birth rates in Venezuela hover around 35 percent as compared to 91 percent in the U. S. Milk production per cow in Venezuela is about 750 kilograms as contrasted to average production in the U. S. of 4,160 kilograms.

As a result of the low animal per unit productivity, considerable amounts of meat and milk are imported to meet a constantly increasing demand. It has been estimated that between 250,000 and 350,000 head of cattle enter Venezuela annually from neighboring countries. Most of the animals enter illegally through farm-to-farm transfer on the frontier, and thus the transactions do not appear in the balance of payments. The tendency has been and continues to be to increase illegal imports. Milk importation also continues, equalling 12,829 tons of powdered milk in 1970, even though national production increased rapidly in the last decade.

Overstocking and overgrazing are major problems in many areas of the country, resulting in general range deterioration and reduced carrying capacity. It has been estimated that in certain areas of the country carrying capacity has been reduced by over 50 percent.

The industry characteristics cited above exist partly because of the tropical ecological conditions found generally in Venezuela, but government policies and programs have also played a part in their formation. The policy of the government, acting through the Ministerio de Fomento, has been to maintain constant retail beef prices. As a result, real (deflated) producer prices, in addition to consumer prices, have fallen. Consumption has been stimulated and production retarded.

Government aid to the cattle industry has occurred principally in the form of subsidized credit through its banking system and through certain animal disease programs. The latter generally have lacked sufficient funds to be effective, and the former has been improperly oriented. Most of the credit funds have been unproductively employed, i.e., purchasing animals and transferring them from one ranch to another. Only 16 percent of the total funds available were used in an attempt to increase the nutritional base of the animals through pasture establishment and improvement.

Both traditional and modern production units, with similar types and breeds of cattle, exist in Venezuela. However, about 90 percent of the cattle are considered to be managed under traditional conditions. Characteristics of average farms in modern and traditional beef and dairy production are given in Table 1. The data are from 221 producer questionnaires taken in the Venezuelan States of Tachira, Merida, Barinas, and Apure.

Stratification between modern and traditional beef herds is based upon the extraction

Table 1. Production characteristics of average farms by type of production

	Unit	Traditional beef	Modern beef	Traditional milk	Modern milk
Livestock inventory		537	104	207	118
Bulls	head	12	2	3	2
Cows	head	251	24	72	40
2–4-yr. old animals	head	96	36	54	17
1–2-yr. old animals	head	95	24	39	24
Calves	head	83	18	39	35
Land inventory (controlled)	hectares	2,095	306	185	141
Land area utilized	hectares	1,673	206	168	98
Cultivated pasture	hectares	101	99	159	79
Natural pasture	hectares	1,572	107	9	19
Total capital investment	B[a]	408,072	117,424	359,381	233,851
Land and pasture	B	124,764	38,746	180,144	117,761
Animals	B	229,167	55,300	131,082	70,976
Machinery & equipment	B	19,966	8,231	20,061	11,518
Buildings & installations	B	34,175	15,147	28,094	33,596
Production					
Milk	lit.	612	415	38,287	57,863
Cheese	kg	290	449	224	1,153
Meat	kg	16,475	9,990	12,568	5,646
Gross income	B	34,254	21,303	50,831	43,855
Total costs	B	26,972	22,662	47,954	32,728
Fixed costs	B	15,024	5,789	21,448	22,606
Variable costs	B	11,948	16,873	26,506	10,122
Net income	B	7,282	−1,359	2,877	11,127
Calf/cow ratio	percent	0.33	0.75	0.54	0.88
Utilized hectarage per animal	hectares	3.1	2.0	0.8	0.8
Total investment/cow	B	1,626	4,893	4,991	5,846
Net income/cow	B	29	neg.	40	278

Source: Questionnaires taken by MAC-FAO in the Venezuelan States of Tachira, Merida, Barinas, and Apure.
[a] B indicates bolivars; one dollar equals about 4.3 bolivars.

rate and calf-cow ratio. Modern units are defined as being those farms with a calf-cow ratio greater than 0.50 and which sell more than 80 kilos of liveweight beef per animal in the herd. The latter implies an extraction rate of approximately 22 percent. Traditional units have calf-cow ratios of 0.50 or less and liveweight beef sales of 80 kilos or less.

Traditional beef ranches are approximately seven times larger in the amount of land controlled by the rancher and five times larger in number of animals. The average traditional ranch produces 31 kilos per year for every animal in the herd, while the modern ranch produces 96 kilos per animal. The calf-cow ratio is 0.33 on the average for traditional ranches and 0.75 for modern ranches. Average net income, the residual return to capital, family labor, and management, on traditional ranches is 7,282 bolivars, or 29 bolivars per cow.[1] Average net income is negative for modern ranches. This unfavorable economic relationship obviously has been a prime factor in the slow shift to modern beef production. It has arisen through government control maintaining beef prices at low levels while allowing input costs to increase with the general level of inflation.[2] The price cost squeeze affects more modern ranches, since they use a much larger percent of purchased inputs than the traditional ranches.

Stratification of dairy farms is based on the calf-cow ratio and milk production per cow. The requirements to be a modern dairy farm were (1) a calf-cow ratio higher than 0.80 and (2) production per cow greater than 1,000 liters. The average calf-cow ratio is 0.54 for traditional milk farms, and production is approximately 560 liters of milk per cow. Corresponding figures are 0.88 and 1,670 for modern farms. Net income is 11,127 bolivars or 278

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[1] One dollar equals 4.3 bolivars.

[2] The deflated producer price index declined from 106.9 to 91.6 during 1960 to 1970. At the same time the deflated index of first quality meat fell from 97.6 to 75.5.

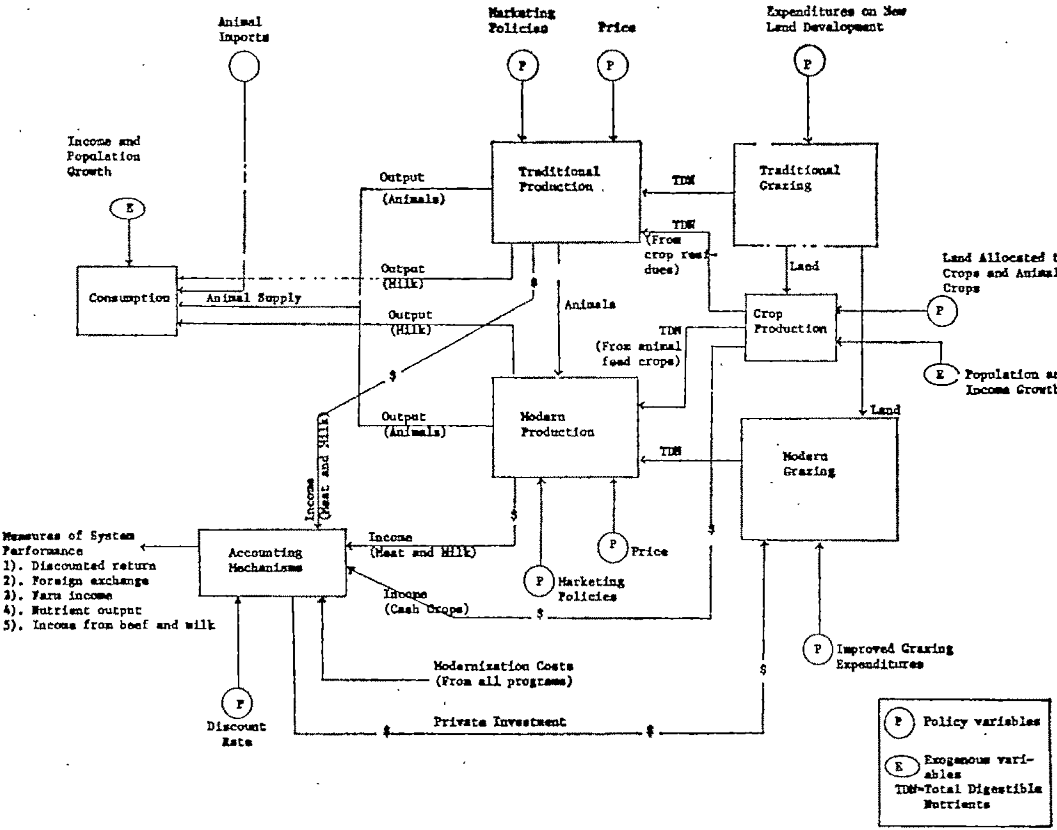

Figure 1. A functional flow diagram of cattle production component

bolivars per cow on modern farms, compared to 2,877 bolivars or 40 bolivars per cow on traditional farms. Since the price of milk has increased over the past decade and technological efficiencies have reduced modern production costs per liter, modern milk production in Venezuela is more profitable than traditional production.[3] As a consequence, total milk production has increased, and the shift from traditional to modern milk production has occurred to a much greater extent than in beef production.

The development problem of the Venezuelan cattle industry is to transform traditional cattle farms into modern ones. The simulation model has been structured like the Nigerian model [5, 6] to test various policies and programs which might speed the transition from traditional to modern production.

Mathematical Modeling

As in the cattle production component of the Nigerian model, the livestock population in the Venezuelan model is disaggregated into two populations—one traditional and one using modern techniques (see Fig. 1). The traditional cattle population is assumed to subsist on grazing land managed in traditional ways. Grazing land and, hence, total digestible nutrients (TDN) for the traditional population, are endogenous model variables related to (1) any food crop acreage expansion required to feed a growing human population; (2) expansion of cash and animal feed crop acreages; and (3) increasing grazing land areas as a result of new land development. Expenditures for new land development and improved grazing are policy variables which can be varied during model tests.

The "condition" of the traditional grazing land, which influences grass yields per acre, is computed as a function of the number of animals grazing on an area relative to an equilibrium number. Male and female livestock populations and sales are computed as functions of calving rates, death rates, and marketing strategies, the latter being policy variables which may be varied during model tests. Calving rates, death rates, and milk output per animal are endogenous model variables determined by the per-animal digestible nutrients supplied by grazing land and crop residues.

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[3] The index of real milk prices at the producer level has risen over the 1960–1970 period, in part through a government subsidy program. In 1960 the producer price index stood at 106.9, increasing to 109.6 by 1970. At the same time the index of real retail prices of pasteurized milk has fallen from 0.96 in 1960 to 0.88 in 1970.

Animals in the modern sector are assumed to be managed under modern conditions, in which adequate nutrition is available from properly managed pastures (productivity in the modern sector is not deteriorating) and supplemental feed obtained from crop land is devoted specifically to animal production. (Land allocated to animal feed crops is a policy variable which can be substituted for land allocated to cash crops—another policy variable.) Land available for modern grazing is determined by public and private expenditures on cultivated pastures and new land developments. Male and female population sizes, sales, birth rates, and death-rates are computed, using virtually the same functional relationships but different input levels, compared to the traditional sector.

In addition to expenditures on improved pastures and supplemental feeding, the model is capable of exploring the consequences of other measures to increase efficiency and output of either the modern or traditional populations in the industry. These include programs to increase grazing areas, and herd management variables which alter sex ratios and/or control population levels to match the available feed supply better.

Several alternative performance criteria which might influence a policy maker's choice of development programs are calculated at both interim and final stages of the simulation experiment. Farm level incomes derived from meat, milk, and cash crops are computed, as are capital investment and operating costs incurred through implementing various modernization policies. Thus several relative benefit/cost relationships for experimental modernization policies are summarized by computed performance functions which include discounted net cash flows, foreign exchange balances, farm incomes, net beef imports, and domestically produced nutrient outputs. The ability of the industry to meet the (forecasted) increase in demand for beef is determined by computing imports necessary to satisfy the projected demand.

The computer program developed at Michigan State University has been modified to run on an IBM computer at the Venezuelan Ministry of Agriculture (MAC) computation center. To correspond to Venezuelan production conditions and to the economic and institutional structure, modifications include the following:

1. Provision is made for the introduction of cultivated pasture rather than grazing reserves as in the Nigerian model. A mechanism has been added for allocating cultivated pasture between the traditional and modern sectors as a function of the relative profitability of animal production in the modern sector.
2. New land for grazing is allocated between modern and traditional rather than to modern only. This allocation is also a function of relative profitability in the modern sector.
3. Milk supply has been made to respond to income derived from milk production by making the proportion of female animals lactating depend upon increases in milk income.
4. Certain kinds of private investments in cattle production, e.g., cultivated pasture and new land, are made endogenous by making them functions of farmers' cash flow.
5. Different types of governmental policies are introduced, e.g., vaccination programs for the prevention of major diseases.
6. A subroutine allows for the possibility of producer and consumer prices of beef to be endogenous, i.e., a free market subroutine.
7. Instructions have been added to the computer program to allow simulating a two-regional breakdown of the herd in addition to the national herd, as was the case of the Nigerian model.
8. Parameters and initial conditions used to characterize production technology, demand, sales, demography, prices, husbandry practices, and land use have been estimated from Venezuelan data and experience [1, 2, 3, 9].

Model Verification

Verification of a computer simulation model is not an easy task; the ultimate test of its validity comes in results from decisions made on the basis of the model. However, insight can be gained on the validity of the model by checking the logic of the model, by comparing computer results with historical data, and by assessing the model's predictive ability from a theoretical and/or common sense standpoint.

The first test of the cattle model consisted of discussing parameter estimates and model structure with qualified scientists and technicians in Venezuela. From their criticism and insight and from sensitivity runs of the model, the structure was modified and the parameter estimates improved until, in their opinion, the model was reasonable and internally consistent. This procedure was repeated throughout the modeling and application experience.[4]

The second test was the comparison of historical data with generated output. This requires a set of unambiguous and generally accepted historical statistical data. Unfortunately such data are not always available, particularly with the Venezuelan cattle population. At least three different estimates are available, one by MAC and one each by FAO and OAS (Organization of American States) [1, 9]. Differences between the estimates are shown in Table 2, along with estimates generated by the model after many trial runs. At one point during the model development the success of the entire undertaking hinged upon being able to generate the MAC sequence.

When the model development began, only the MAC estimates were available to the modelers. Having tried unsuccessfully for some time to generate the MAC data, the modelers told the director of the Livestock Project that there must be an error in Venezuela's federal statistical report. He agreed, and said that if the model had been able to generate the MAC data, he would have had little confidence in the model. He then reached into a drawer of his desk and provided a publication that contained generally more acceptable estimates. Upon comparison with estimates from the model, the FAO and OAS estimates were similar, as seen in Table 2. This experience was the most convincing evidence found for accepting the model structure and was used subsequently to illustrate the model's validity to decision-makers.

Discrepancies between the MAC estimates and those of FAO and OAS were explained by animals being counted on farms by MAC when, in fact, they were brought into Venezuela from neighboring countries. Because these imported (smuggled) animals stayed on farms only a short time, they did not represent the basic Venezuelan cattle population nor a component of the off-take. Other historical data series, too numerous to reproduce here, were also checked, e.g., demand for beef and milk, importations of beef cattle and milk, and hectarage of cultivated pasture.

Table 2. Venezuelan cattle population, 1961–1970

Years	Estimates of MAC (1,000 animals)	Estimates of FAO (1,000 animals)	Estimates of OAS (1,000 animals)	Estimates of the model (1,000 animals)
1961	6,519	—	6,519	6,519[a]
1962	6,724	—	6,502	6,530
1963	6,936	—	6,572	6,600
1964	7,155	—	6,650	6,720
1965	7,380	6,735	6,735	6,850
1966	7,612	6,822	6,822	6,950
1967	7,852	6,911	6,911	7,020
1968	8,102	—	7,000	7,070
1969	8,289	—	—	7,100
1970	8,499	—	—	7,110

[a] Initial condition of model.

A third test of the model's validity was to subject the model to various kinds of exogenous shocks which had not been historically observed and then compare the results with experts' common sense or intuitive judgments concerning the likely outcomes of the shocks when applied to the real system. Such shocks include governmental programs and policies. Introduction of an entirely new institution, such as a free market, into a previously controlled situation can be checked against general outcomes predicted by economic theory. Results presented in the subsequent section illustrate the types of shocks to which the computer model was subjected and the types of behavior produced.

Model Application

After the model was refined and the first two validity checks were made, a computer run was made to establish a base against which all other experimental runs could be compared. Experimental runs incorporated various policy and program alternatives. The base run started with initial conditions as of 1961, and the computer program generated the historical period to 1970 and then the projected period to the year 2001. A graph of the base run showing the total population, the traditional herd, the modern herd, and the supply and demand of animals is reproduced in Figure 2. The values of these variables in 2000, as well as others useful for policy-making purposes, are shown in Table 3.

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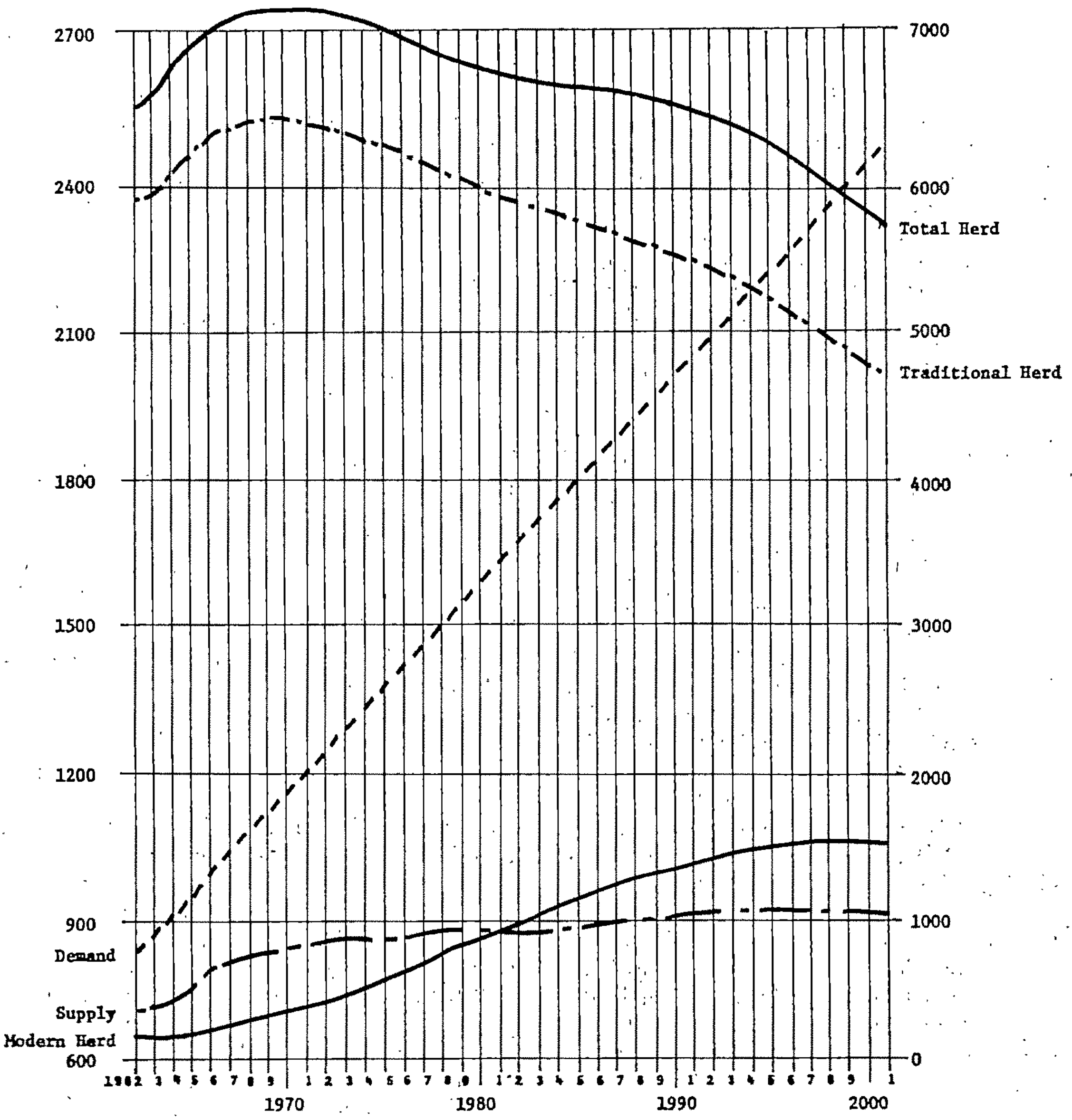
[4] Numerical estimates of parameters were provided by the authors and various experts and were subsequently refined through sensitivity runs of the model.

The urgency of creating a viable active program by the government for the cattle industry was apparent to decision-makers from the results. Total animal population has probably reached its maximum and will soon start to fall, decreasing to a total herd of 5,850,000 head in the year 2000. This constitutes a reduction of 17.5 percent from an estimated 1972 herd. Loss of population occurs in the traditional herd, falling 25.1 percent in the 28-year period and reaching 4,780,000 in the year 2000, because of increasingly poorer range conditions and increased competition for the use of traditional pasture. In the year 2000 the range index is calculated to be only 65.7 percent of what it was in 1961, while traditional pasture land decreases 19.7 percent from 1972. Thus nutrition intake is low, averaging in the year 2000 only 879 kilos of consumed TDN per animal. Average range density is calculated to be 2.55 hectares per animal.

As the traditional population falls, the mod-



Note: All figures are expressed in thousands. Scale of lines labeled on left is given on left. Scale of lines on right labeled on right.

Figure 2. Basic run of Venezuelan cattle component

Table 3. **Comparison of alternative campaigns and programs to increase livestock productivity with the base run in the year 2000**

		Base run value of variable	Alternative V R Comb 6 percent of B. run	Alternative VI R Comb 7 percent of B. run	Alternative VII R Comb 8 percent of B. run
1. Supply beef (SUP)		904,000 head	156.0	*169.2*[a]	161.5
2. Demand beef (DEM)		2,430,000 head	*92.6*	64.2	58.8
3. Price per head to producer (PA)	B[b]	550/head	115.5	154.4	*156.0*
4. Retail price per head (PAR)	B	662/head	108.6	154.1	155.6
5. Total herd (TP)		5,850,000 head	100.7	102.2	101.5
6. Traditional herd (TTP)		4,780,000 head	*65.9*	56.9	60.9
7. Modern herd (YMP)		1,070,000 head	256.1	*304.7*	284.9
8. Extraction rate		.155	154.4	*165.1*	158.6
9. Supply milk (QM)		1,020,000,000 kg	204.9	*230.4*	222.5
10. Demand milk (DEMM)		2,020,000,000 kg	100.0	100.0	100.0
11. Range condition (RCON)		.657	110.2	109.3	110.4
12. Nutrition modern, TDN/animal (TDNAM)		1,360 kg/head	100.0	100.7	100.7
13. Nutrition traditional, TDN/animal (TDNAT)		879 kg/head	122.9	124.0	125.1
14. Grazing rate traditional (hectare per animal) (GRT)		2.55 ha/head	103.5	98.4	102.0
15. Cattle income net of cash expenses (CFFAR)	B	730,000,000 per year	195.9	246.6	*265.8*
16. Discounted accumulated cattle income (AVDPT)	B	4,540,000,000	138.8	152.4	142.1
17. Discounted accumulated investments (private and public) (ADEX)	B	1,170,000,000	191.5	217.1	198.3
18. Accumulated foreign exchange (cattle products) (FOREXA)	B	25,900,000,000	42.1	7.4	21.9
19. Value of cattle and associated land (VALCAP)	B	5,240,000,000	116.8	143.9	143.5
20. Land in modern cattle production (LGM)		2,650,000 ha	232.8	282.3	262.3
21. Land in traditional cattle production (LGT)		12,200,000 ha	68.5	56.1	62.3
22. Cultivated pasture (LCG)		8,810,000 ha	164.9	*162.7*	165.7
23. Meat per capita from domestic supply (TMPCS)		5.3 kg/capita	171.9	*190.2*	180.4
24. Meat per capita from domestic supply and imports (YMPC)		13.7 kg/capita	*105.8*	75.2	67.9
25. Imports of beef (IMP)		1,530,000 head	54.6	*1.8*	−2.0
26. Imports of milk (IMM)		1,000,000,000 kg	−7.6	−3.3	−2.6

[a] Italicized values refer to "best" of the three alternatives for an objective given by that line.

[b] B indicates bolivars; one dollar equals about 4.3 bolivars.

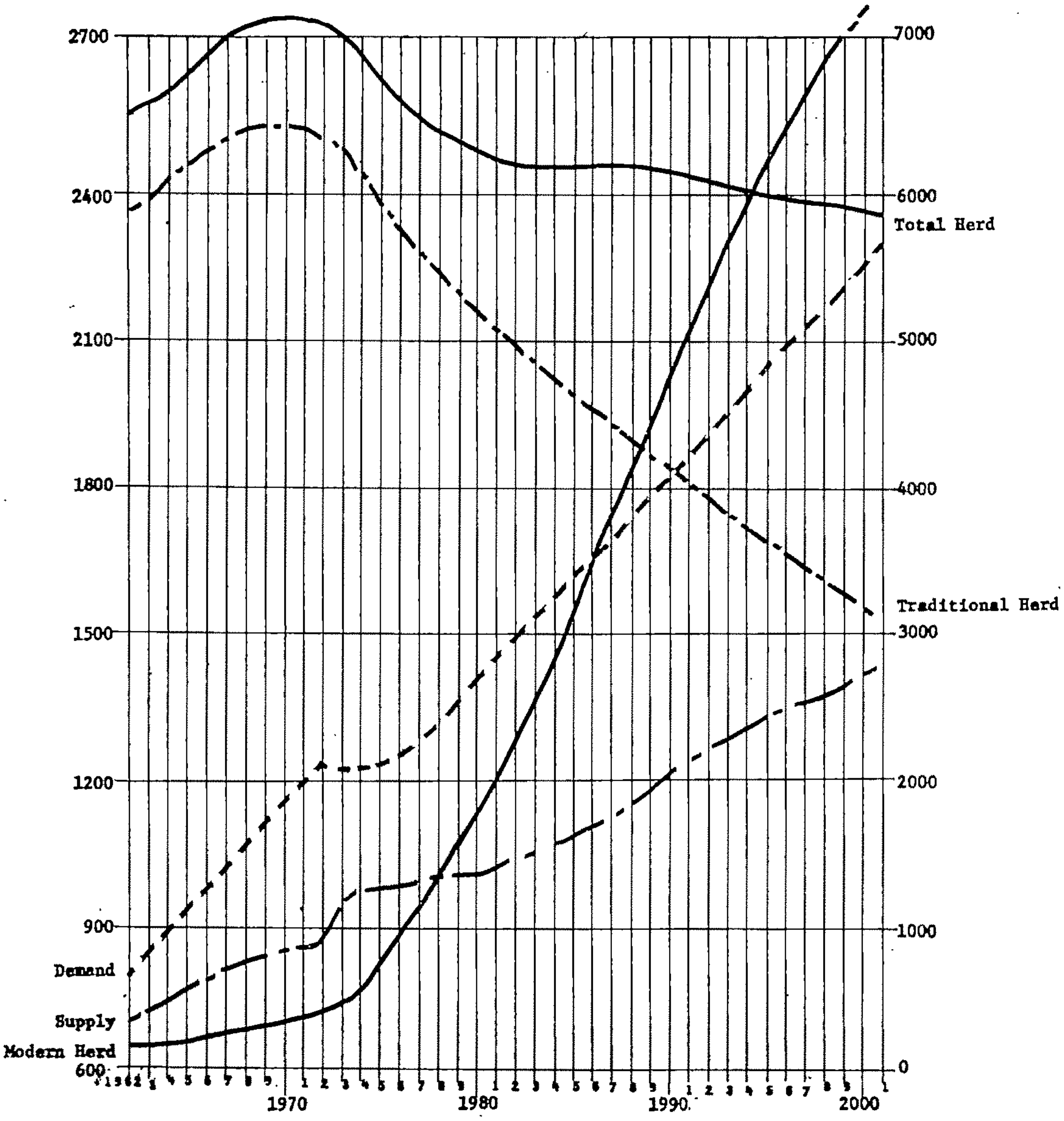
ern population increases (see Fig. 2). During the 28-year period, modern (cultivated) pasture land increases 27.0 percent. The nutritional level for the modern herd also increases because of an even faster increase of land shifted from traditional to modern production (55.9 percent). TDN consumption per animal per year reaches 1,360 kilos in the year 2000. The increasing modern herd, however, does not expand enough to change the downward trend in the total population.

Animal off-take increases but still remains very low. By the year 2000 it will be only 15.5 percent. As a result of the low off-take and decreased total herd, the increase in domestic supply of beef is also small—904,000 head by the year 2000, up only 7.6 percent from the 1971 slaughter. It will provide a per capita consumption in that year of only 5.3 kilos of domestically produced beef.

Demand for beef will continue to grow through increased population and per capita income, with a demand for 2,430,000 head anticipated by the year 2000. As a result of the increasing deficit between rapidly increasing demand and nearly constant level of domestic production, importation of animals by 2000 will increase to 1,530,000.

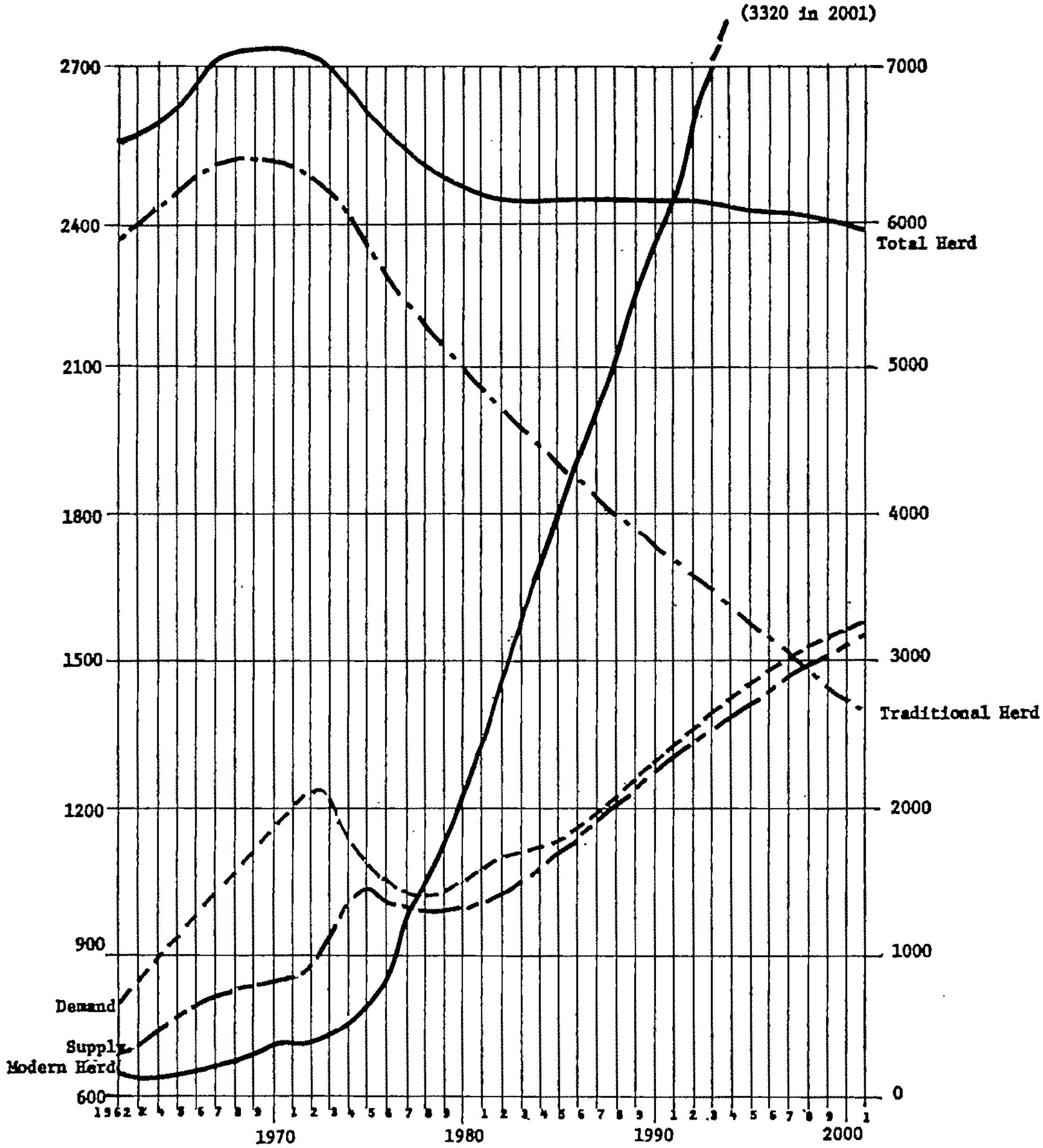
Milk supply also levels off. A production of 1,020,000 tons of fluid milk are produced in 2000. By that time, however, demand will have grown to 2,020,000 tons, necessitating an importation of the residual 1,000,000 tons. Importation of milk and beef will obviously be a major leakage and cause a serious strain in the national balance of trade.

Cattle income net of cash expenses will reach 730,000,000 bolivars per year, a 68.6 percent increase from 1972. Value of the cattle and associated land will decrease 13.1 percent, being 5,240,000,000 bolivars in the year 2000 as a result of decreased cattle numbers. Discounted accumulated investments in pasture development from both private and public sources will



Alternative V

Figure 3. Price policy 1, pasture improvement program, herd management campaign, new land program, and shift to modern methods campaign



Note: All figures are expressed in thousands. Scale of lines labeled on left is given on left. Scale of lines on right labeled on right.

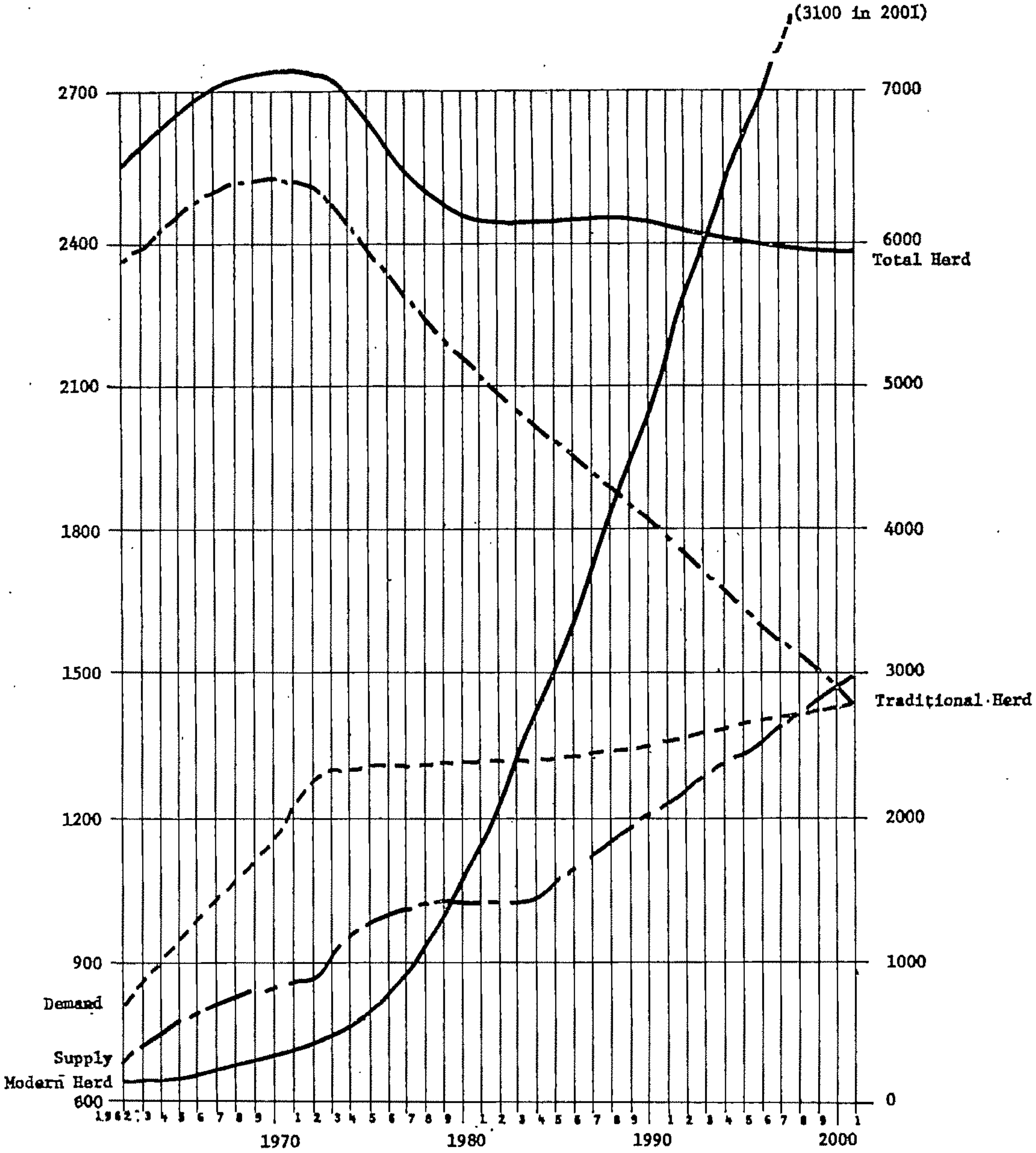
Alternative VI

Figure 4. Price policy 3, pasture improvement program, herd management campaign, new land program, and shift to modern methods campaign

amount to 1,170,000,000 bolivars (the investment stream was discounted at the rate of 8 percent).

Policy alternatives

In general the policy runs include price policy alternatives, production campaigns and extension, subsidy or direct government investment, research programs, and disease control projects. While this is not an exhaustive list of possible policy alternatives, it should be considered as illustrative of the types of policies and programs that can be tested. Policies and programs are introduced as of 1972, or the 11th



Note: All figures are expressed in thousands. Scale of lines labeled on left is given on left. Scale of lines on right labeled on tight.

Alternative VII

Figure 5. Price Policy 2, pasture improvement program, herd management campaign, new land program, and shift to modern methods campaign

year of the simulation run, and results are generated for 30 years to 2001.

The price policies include (1) increasing the price to producers approximately 15 percent (550 to 635 bolivars per head) in 1972 and reducing the marketing margin ratio from 1.204 to 1.133, i.e., the ratio of the retail price per head to the producer price per head; (2) increasing the producer price at the rate of 2 percent per year from the 1972 base price; and (3) allowing the free market to determine producer prices.

Production campaigns and extension include information programs to modify herd management and to shift cattle production from traditional to modern methods. Government subsidies or investment include an animal feed supplement program, a pasture improvement program (increasing cultivated as contrasted to natural pasture), and deforestation and subsequent introduction of new land. The research program involves increasing the productivity of pasture land in the modern sector. A specific disease project as proposed by the Dirección de Ganadería, MAC, was simulated using the base model and in conjunction with the first price policy and the other campaigns and programs.

Several combinations of the policies and programs were simulated. Starting with the 15 percent price increase program, policies or programs were added one by one. Then, with the full complement of programs, the price policy was changed to 2 percent increase per year and finally to the free market price.

Five variables—demand, supply, modern herd, total herd, and traditional herd—were plotted on graphs to illustrate the impacts or increments that each policy or program had on each variable. These graphs were reproduced on 30 by 42 inch plastic overlays so that comparisons could be made between policy alternatives. These large graphs were used extensively to communicate the outcomes of policy alternatives to governmental officials, ministers, the country's president, and to the news media. Unfortunately the presentation is more restricted here. Shown in Figures 3, 4, and 5 are graphs of the five variables for each of the three price policies when all other programs are included. In Table 3 the three alternatives are compared with the base run. Values of selected variables are shown for the base run for the year 2000, and the outcome for each alternative is expressed as a percentage of the base run. This, too, is a much abbreviated version of the original table.

Although many interesting comparisons can be made from Table 3 (see italicized numbers), there are conflicts between the alternatives in attempting to achieve a set of multiple objectives. For example, Alternative V maintains consumption per capita and has the largest traditional herd. Alternative VI maximizes consumption per capita from domestic supply, has the largest modern herd with a large hectarage of cultivated pasture and the largest extraction rate, and the smallest foreign trade deficit. Alternative VII provides the highest price to producers and the greatest cattle income net of cash expenses. The conclusion is that while computer simulation is a powerful tool in the decision-making process, it is not a replacement for the decision-maker.

Government implementation

Results from the "shock" tests of the model were reviewed by various experts and policy makers. In addition, the results were shown to cattlemen's associations, professional associations, university personnel, and local government officials [7, 8]. While the authors participated in some of these presentations, the director of the Livestock Project and the Director of Agriculture of CORDIPLAN, the national planning agency, were most prominent in presenting the results.

In August 1972, approximately a year from when model development was undertaken, the government announced an increase in the price of beef to producers and consumers and a reduction in the marketing margin. The percentage increase in the price is uncertain, in that different prices were set for different grades of meat, the percentages of which are unknown at this time since historically no grading was done. In addition, it was announced that over 600,000,000 bolivars were being allocated to credit programs for pasture improvement and improved cattle management. This is equivalent to the accumulated amount over the past 10 years of monies allocated for these purposes. The new programs include disease prevention campaigns and a classification of meats into various grades. The final form of the entire program has not been specified, but the computer model is likely to play a further role in the development of the combination of programs to be carried out.

The announcement of the price increase *and* the new livestock programs have caused an uproar in the newspapers and on television. At this writing, the opposition parties to the one in power have promised that the problems of the Venezuelan cattle industry and their possible solutions will be an issue in the 1973 presidential election campaign. Whether the final outcomes, in reality, are anything like the model's prediction, the model and the results have had some impact upon prompting the government to make some necessary decisions about development of the Venezuelan cattle industry. As technicians and problem solvers, the authors have tried to stay clear of political events but have provided the decision-makers with likely consequences of a number of alternatives. These alternatives are not, by themselves, value-laden entities; only the consequences of actions taken by decision-makers lead to the choice where relative good is balanced against ultimate evil. Happily, the decision-making has been left to the decision-maker.

References

[1] *Anuario Estadistico Agropecuario*, Ministerio de Agricultura y Cría, Caracas, 1970.

[2] Consejo de Bienestar Rural, *Venezuela—Agricultural Supply and Demand Forecasts*, Caracas, 1965.

[3] COPLANARH, *La Agricultura Deseable: Una Prospección del Año 2000*, Pub. No. 19, Comision del Plan Nacional de Aprovechamiento de los Recursos Hidráulicos, Dec. 1970.

[4] HALTER, A. N., M. L. HAYENGA, AND T. J. MANETSCH, "Simulating a Developing Agricultural Economy: Methodology and Planning Capability," *Am. J. Agr. Econ.* 52:272–284, May 1970.

[5] MANETSCH, T. J., M. L. HAYENGA, AND A. N. HALTER, "A Simulation Model of the Nigerian Beef Industry," Michigan State University, 1968, mimeo.

[6] MANETSCH, THOMAS J., *et al.*, *A Generalized Simulation Approach to Agricultural Sector Analysis with Special Reference to Nigeria*, Michigan State University, E. Lansing, Nov. 30, 1971.

[7] MILLER, S. F., *et al.*, "Computer Simulation as a Decision-Making Tool for Development of the Venezuelan Cattle Industry, Part II," 2nd Annual International Zebu Conference, Caracas, Aug. 1972.

[8] SEGURA, J. J., *et al.*, "Computer Simulation as a Decision-Making Tool for Development of the Venezuelan Cattle Industry, Part I," 2nd Annual International Zebu Conference, Caracas, Aug. 1972.

[9] "Una Ganaderia Rentable: Precios y Comercio Internacional," *Revista Cebu*, Sept. 1971.

Economic Aspects of a Nuclear Desalination Agro-Industrial Project in the United Arab Republic*

DUANE CHAPMAN

The purpose of the study is to investigate the financial feasibility and social benefits and costs of nuclear desalination agro-industrial projects. As presently designed, such a complex appears to require deficit financing, provide little employment, retard national income growth compared to other investment opportunities, and increase the foreign exchange deficit.

THIS paper reports the results of an empirical study of nuclear desalination agro-industrial projects. In recent years the possibility of desalting sea water to produce irrigation water for large-scale commercial agriculture and industry has attracted wide attention as a means of stimulating cooperation and economic development in the Middle East. Eisenhower supported the possibility [6], and it has received varying degrees of attention in the Committee on Foreign Affairs of the House of Representatives [19] and the Committee on Foreign Relations of the United States Senate [20].

Previous studies have offered contradictory opinions on the economic feasibility of such projects. Fried and Edlund believe that it is technically and economically feasible to convert coastal desert land in Egypt into highly productive agricultural land through a large-scale desalting program [7, p. 84]. An opposing point of view held by Clawson *et al.* is that such proposals are not economically practical and in fact are "a distinct disservice to the people of the region" [5, p. 116].

Conceptual Approach

This study employs financial feasibility and national income benefit analysis.[1] The financial analysis determines project investment and operating costs, revenues, cash flows, and profitability with likely market prices and government policies. The benefit-cost analysis examines the effect of the project on macroeconomic goals such as employment, foreign trade, capital scarcity, and national income.

El-Hamman, 30 miles west of Alexandria, was selected as a potential project site because of its soil characteristics, present unsettled status, and nearness to market and port facilities. Project design was carried forward in three simultaneous phases: (1) selection of agricultural and livestock commodities for maximum profit from use of project water; (2) examination for maximum profit of industries—such as steel, aluminum, elemental phosphorus, and ammonia—that have electric-intensive production processes; and industries—such as solar salt, caustic chlorine, magnesium, nitrogenous and potassic fertilizers, and bromine—that use seawater; (3) engineering examination of 500 megawatt electric power plants (both oil fired and nuclear) operated in association with 100 or 200 MGD (million gallons per day) desalination plants to determine least costly methods of production. The 200 MGD nuclear facility was selected for detailed analysis. Goal functions employed in the analysis are separable (and probably strongly so) into these three groups. Within the context of the indicated commodities and production processes, it is unlikely that the results of an attempt at overall optimal design would have been significantly different from those of the separate optimizations outlined here.

Financial Analysis

Initial investment costs total $400 million (see Table 1) and are invested over a seven year construction period. Annual production,

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* A lengthier version of this paper was presented at a seminar of the International Center for Marine Resources Development at the University of Rhode Island on April 12, 1972. Thanks go to C. C. Burwell, Naiem Sherbiny, John Moyers, Roger Woodworth, and other members of the Middle East Study Group at the Oak Ridge National Laboratory for their dedication and cooperation. Robert Kalter, Timothy Mount, Gavan Butler, the reviewers, and an editor are thanked for their comments, as is Jeanne M. Ostro for her assistance. This paper reports on research undertaken at the Oak Ridge National Laboratory through the support of the Agency for International Development and the Atomic Energy Commission and the Union Carbide Corporation. The research had been classified from 1970 until April 1972. Views expressed here are solely those of the author.

[1] There is much current interest in other project evaluation criteria such as regional development, environmental quality, and income distribution. Given the analysis here, these criteria are clearly moot in this particular case.

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Table 1. Initial investment cost, 1969 prices

Item	Domestic currency	Foreign currency	Total
	-------- million dollars --------		
Nuclear steam supply system	25.6	63.9	89.5
Electrical plant	24.4	61.5	85.9
Evaporator plant	17.0	86.0	103.0
Chemical facilities	32.2	21.6	53.8
Farm	51.4	8.0	59.4
Working capital	3.1	0.5	3.6
Total	153.7	241.5	395.2

Source: [4].

revenues, and costs of agricultural and industrial commodities are shown in Table 2.

Yield estimates are based upon specific assumptions of crop variety, soil, climate, water use, and cultivation techniques. They are generally higher than recent UAR (United Arab Republic) and Israeli yields and lower than current record yields. Mechanization is "intermediate" between that in the U. S. and the UAR. Price estimates were generally at UAR levels, with reductions made for crops such as cotton and grapefruit with anticipated future world price reductions.

Table 3. Receipts and operating costs for representative year, 1969 prices

	Domestic currency	Foreign currency	Total
	-------- million dollars --------		
	Receipts		
Farm products	31.5	7.1	38.6
Chemicals	6.1	7.2	13.3
Electricity	19.9	0	19.9
Total Receipts	57.5	14.3	71.8
	Operating costs[a]		
Nuclear steam supply system	0.5	0.5	1.0
Electrical plant	0.3	0.3	0.6
Nuclear fuel	0	6.6	6.6
Evaporator plant	0.7	0.7	1.4
Chemical facilities	1.4	0.5	1.9
Farm	16.2	2.1	18.3
Total operating costs	19.1	10.7	29.8
Net receipts	38.4	3.6	42.0

Source: [4].

[a] Includes replacement investment cost.

Most industrial products cited above were rejected because of distance from raw material sources and/or markets. Table 3 shows re-

Table 2. Selected production characteristics of UAR agro-industrial complex design with full capacity production and 1969 prices

Commodity	Yield lb/acre	Price $/cwt	Annual production (1000 cwt)	Annual revenue ($1000)	Direct annual cost ($1000)
Wheat	6,000	3	1,411	4,234	1,183[a]
Corn	9,000	2.2	119	261	847[a]
Raw cotton	3,090	10	463	4,632	1,515
Peanuts	3,800	7	462	3,237	1,180
Oranges	44,000	3	440	1,320	512
Broad beans	3,420	5	855	4,275	1,650
Spring potatoes	43,200	1.5	3,025	4,536	2,359
Winter potatoes	27,000	2	270	540	321
Tomatoes	52,000	1.2	520	624	341
Onions	33,200	1.9	1,992	3,780	1,866
Cantaloupes	18,000	4.5	90	405	223
Milk	—	5	1,080	5,400	2,475
Cull cows	—	$188 ea	1,980 ea	380	[b]
Calves	—	$ 15 ea	5,300 ea	80	[b]
Eggs	—	$0.35/doz	5.4 mil doz	1,890	1,113
Cull hens	—	$0.54 ea	0.25 mil	135	[c]
Broilers	—	19.5	147	2,860	1,575
Electricity	—	5.8 mills per KWH	3.43 bill KWH	19,900	622
Crude salt	—	0.125	31,600	3,950	1,888
Refined salt	—	1.0	6,570	6,570	[d]
Caustic	—	3.0	940	2,820	[d]

Source: [4].

[a] Includes corn and wheat grown for feed.

[b] Included in milk production cost.

[c] Included in egg production cost.

[d] Included in crude salt production cost.

ceipts and operating costs for a representative year of full production.[2]

These costs and revenues are included in the first six columns in the cash flow summary of Table 4.[3] Capital investment is naturally concentrated in the early years, but replacement investment occurs throughout the life of the project. Most notable is the foreign currency investment of $16 million each in 1992 and 1993 for replacement evaporators in the desalination plant. At the end of the production period in 2007, the farm has a resale value of $19 million. Also of interest is the salvage of nuclear fuel, which returns $2–3 million each year from 2008 through 2011. Operating costs are relatively constant over time. Fourteen years are necessary for agricultural output to reach full production, but electricity and chemicals are assumed to be produced at capacity levels in the first year of operation in 1978 and thereafter.

Domestic taxes might be applied to profit, gross receipts, value added, or property. In the first repayment analysis, the *Guide for Economic Evaluation of Nuclear Reactor Plant Designs* [13, pp. 2–5] is followed. Annual tax is computed at 4.88 percent of the value of investment capital (column 7). The tax assumption varies in subsequent analyses.

Price controls have limited inflation in the UAR. From 1959 to 1969 the consumer price index increased 2.9 percent per year [21]. This was assumed to be valid for all domestic project costs and revenues and foreign operating costs and revenues and is the basis for the price index in column 8. The Bechtel Corporation estimated that capital costs for the project would increase 8 percent per year indefinitely [1, pp. 11–12]. It is assumed here that foreign capital costs increase 8 percent per year through the construction period and that the rate of increase slows 0.5 percent per year until it reaches the 2.9 percent per year domestic inflation rate (column 9).

Price indices are utilized to define the actual net expenditures or income in columns 10 and 11. The tables indicate cost and revenue esti-

Table 4. Repayment analysis summary with original assumptions, 1971–2011

Year	Domestic capital investment (1)	Foreign capital investment (2)	Domestic operating costs (3)	Foreign operating costs (4)	Domestic sales (5)	Export sales (6)	Domestic tax (7)	Basic cost and revenue price index (8)	Foreign capital price index (9)	Actual net domestic revenues (10)	Actual net foreign revenues (11)	Domestic interest earnings (+) or charges (−) (12)	Foreign interest earnings (+) or charges (−) (13)	Domestic debt (−) or surplus (+) at year's end (14)	Foreign debt (−) or surplus (+) at year's end (15)
	--------	--------	--------	million dollars in 1969 prices	--------	--------	--------	----1969 =	1.00----	--------	--------	million dollars in actual future prices	--------	--------	--------
1971	0.000	3.306	0.000	0.000	0.000	0.000	.0000	1.0588	1.1664	0.0000	−3.8561	0.0000	0.0000	0.0000	−4.0489
1976	46.861	79.358	0.000	8.747	0.000	0.000	0.0000	1.2215	1.7138	−57.2426	−145.2673	−5.9890	−17.5750	−125.7687	−369.0756
1981	0.623	0.548	15.900	8.280	48.491	13.418	19.3069	1.4092	2.4488	17.8425	4.0984	−11.4461	−27.5203	−222.5261	−573.8271
1986	1.337	0.149	17.986	11.071	56.136	14.212	19.3069	1.6258	3.1250	28.4611	2.8602	−8.3084	−35.0064	−146.0163	−732.2748
1991	0.071	0.136	18.043	11.064	57.464	14.364	19.3069	1.8756	3.6297	37.5927	3.0005	−2.0074	−44.4387	−4.5621	−930.2128
1996	1.034	0.112	18.043	10.568	57.464	14.364	19.3069	2.1638	4.1875	41.2853	3.5504	0.0000	−57.6772	0.0000	−1171.7525
2001	0.232	0.145	18.043	11.854	57.464	14.364	19.3069	2.4963	4.8309	49.6312	1.9572	0.0000	−63.2179	0.0000	−1282.4406
2006	0.045	0.005	18.043	10.776	57.464	14.364	19.3069	2.8798	5.5732	57.7959	3.7713	0.0000	−68.1528	0.0000	−1377.1553
2011	0.000	0.000	0.000	−2.840	0.000	0.000	0.0000	3.3224	6.4296	0.0000	3.0071	0.0000	−74.5083	0.0000	−1561.6674

Source: [4].

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[2] The agricultural analysis summarized here was prepared by R. C. Woodworth, T. Tamura, and C. M. Farmer [24]. The industrial products analysis was prepared by H. E. Goeller, the Union Carbide Corporation, and J. C. Moyers [8].

[3] Table 4 presents in summary form every fifth year of a complete cash flow which estimates each item in Tables 1–3 for each year, 1971 to 2011 [4].

mates for domestic UAR currency and foreign (primarily U. S.) currency. The bulk of initial investment is in foreign currency, while net receipts are essentially in domestic currency. It is reasonable to assume that foreign borrowing, purchases, and sales would be undertaken through accounts distinct from domestic accounts. Traditional foreign lenders such as commercial consortia, international banks and development funds, and foreign governments are conceivable investors. The exchange rate of $2.30=£E existing in 1970 was probably too high; the UAR has a large recurring balance of payments deficit. It is here assumed that domestic earnings might retire foreign debt at a ratio of 0.87 to 1 (i.e., an exchange rate of $2.00=£E). After discussions with financial experts in UAR development financing, a 5 percent rate was selected as a possible annual interest charge on foreign and domestic investment.[4]

Accounts open in 1971 when design work is assumed to begin on the nuclear power, evaporator, and chemical facilities. Accounts close at the end of 2011 when the last of the unused reactor fuel will have been sold. All foreign earnings are applied to the foreign account. Because of the foreign exchange problem, domestic earnings are first used to retire domestic debt. Subsequently they are applied to foreign debt at the 0.87 conversion factor. Interest is charged to accumulated debt at the end of each period and to any excess of costs over revenues when debt exists. If foreign debt is retired, both accounts accumulate surplus and interest earnings separately. These definitions result in the remaining four columns in Table 4. As a consequence of these assumptions, domestic debt is retired in 1992, but foreign debt grows throughout the period until it reaches $1.6 billion at the end of the project (see Tables 4 and 5).

It is simple to program these relationships (see Appendix) in order to examine the sensitivity of the results to changes in assumptions. Suppose the fixed capital tax is replaced by a value added tax. In the latest year with available data (1960), the ratio of (a) tax payments by all producing units to the government, divided by (b) total value added by all economic activity was .229.[5] For a project, value added is wages plus annual net return before taxes. With a 22.9 percent annual value added tax replacing the annual fixed capital tax, foreign debt falls to $283 million by 2011.

Further tax assistance might be offered by setting taxes at 5 percent of gross receipts. In this case surpluses accumulate. Domestic surplus reaches $645 million and foreign surplus is $57 million at the end of the project.

Other financial arrangements might be undertaken in which the original fixed capital tax is used. If foreign components of the nuclear steam supply and the electrical plant are donated and domestic earnings are accepted

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[4] Official exchange rate as of August 1, 1972 was $2.35 =£E. This reflects both the absence of a UAR devaluation and the recent U. S. devaluation. The approach here and in the benefit-cost analysis following is analogous to the shadow exchange rate of McGaughey and Thorbecke [11, pp. 33–36]. These questions were discussed at a seminar to consider financial analysis on September 28–29, 1969. Personnel with Middle East responsibilities in an international development fund, a U. S. Development Agency, and a commercial bank participated [14, 15]. Also, see Chandavarkar [3].

[5] The .299 figure is calculated from data in Mead [12, p. 276].

Table 5. Summary of repayment analyses with assumed actual future prices[a]

Repayment assumptions	Year domestic debt retired	No forgiveness, end of project[b] debt (−) or surplus (+) Domestic ($1,000,000)	Foreign ($1,000,000)	Foreign debt forgiven Year	Amount ($1,000,000)
Original	1992	0.0	−1561.7	1978	461.7
Tax=22.9 percent of value added	1986	−13.4	−282.6	2009	251.2
Tax=5 percent of gross revenue	1984	645.3	57.3	[c]	[c]
Donated foreign nuclear and electrical investment, official exchange rate	1992	0.0	−160.6	2009	145.7
No interest on foreign capital	1992	192.3	78.5	[c]	[c]

[a] Beginning of year basis.
[b] Project ends in 2011.
[c] Surplus.

for remaining foreign debt, then that debt is \$161 million at the end of 2011.

Suppose no interest is charged or accrues to the foreign account. Here a surplus results of \$192 million domestically and \$78.5 million in the foreign account.

Five analyses are summarized in Table 5. Included is foreign debt forgiveness for the year with minimum foreign debt. This amount indicates the smallest debt that could be written off as a grant subsidy to enable the project to operate to its termination and leave no outstanding debt. For example, in the original case either \$461.7 million dollars could be forgiven in 1978 or the project would come to its end in 2011 with \$1.562 billion in outstanding foreign debts. Financial viability apparently requires substantial tax assistance, foreign capital donations, or both.

National Income Benefits and Costs

Particular economic objectives to be considered are national income, employment, capital scarcity, and foreign trade.

There are three categories of domestic employment in the complex: construction labor, agricultural labor, and skilled technicians and engineers. In each case it seems likely that unemployment or substantial underemployment characterizes UAR labor markets. Therefore it is assumed that the wages of such labor add value to national income.[6] Admittedly this is a controversial position. The cited evidence is weak. It might be argued that some fraction less than one is the correct proportion of domestic wages that is an addition to national income. As noted below, the particular asssumption employed makes little difference in the conclusions. Domestic wages total \$50.6 million during construction and are \$3.1 million annually during project operation. Direct employment would be 9000 man-years per year during production.

A social discount rate of 10 percent is consistent with benefit-cost analysis in developing countries in general [11; 10, p. 184] and the UAR in particular [16]; it is utilized here.

The UAR has a chronic foreign exchange deficit and is at times unable to import needed fertilizers, replacement parts, and other industrial necessities because of this [17, 21]. By taking the preceding discussion of convertability as a guide, imports are penalized 15 percent and exports and import substitutes are given a premium of 15 percent. (At full production, domestic import substitute sales are \$6.5 million of a total \$57.5 million domestic sales.)

It is generally assumed in benefit-cost analysis that inflation affects all benefits and costs equally; therefore, the sign of net benefits and the size of the benefit-cost ratio are unaffected. However, the discussion of inflation above suggests that the nuclear steam supply, evaporator, and other foreign capital prices will increase faster than other prices. This greater rate of increase is 5.1 percent (8 percent minus 2.9 percent) through 1977, and the rate of increase decreases 0.5 percent annually until it stabilizes at zero. Thus there is an overall 1969 price base with an allowance for relative price increase in foreign capital components.

Particular measures of national income benefits and costs used here are net present value, benefit-cost ratio, and internal rate of return. They are defined as follows:

$$B = \sum_{t=1}^{41} \sum_{i=1}^{4} B_{it}(1 + r)^{-t} \tag{1}$$

$$C = \sum_{t=1}^{41} \sum_{k=1}^{4} C_{kt}(1 + r)^{-t} \tag{2}$$

$$N = B - C \tag{3}$$

$$BCR = B/C \tag{4}$$

$$IRR = [r: B = C] \tag{5}$$

where t is each year of the time horizon from the beginning of design and construction to the end of production and liquidation of salvageable assets; B is present value of benefits at beginning of year 1; C is the same for costs; N is the net present value of benefits and costs; BCR is the benefit-cost ratio; r is the social discount rate; IRR is the internal rate of return (the social discount rate such that the present value of benefits exactly equals the present value of costs); B_1 is export sales increased by 15 percent premium; B_2 is import substitution sales increased by 15 percent premium; B_3 is other domestic sales; B_4 is domestic wages; C_1 is import purchases of capital goods adjusted by price index and increased by foreign exchange penalty; C_2 is import purchases of operating supplies in-

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[6] See [21; 12, pp. 31–41]. This view is taken in unpublished research by C. Nader and N. A. Sherbiny. A partly contradictory view is held by Hansen [9].

Table 6. Benefit-cost analysis summary

Social discount rate	Present value of benefits	Present value of costs	Net benefits	Benefit cost ratio
percent	million dollars			
10	364.5	494.2	−129.7	0.74
15	187.2	342.2	−555.0	0.55
5	826.5	801.4	25.1	1.03
5.45	762	762	0	1.00

creased by penalty; and C_3 and C_4 are domestic capital and operating expenses.

Since gross national product is the sum of value added, net present value can be interpreted here as the present value of direct GNP changes adjusted for foreign exchange premiums and penalties.

The first row of Table 6 shows the results, which are clearly uncomplimentary; net benefits indicate a loss of $130 million, and the benefit-cost ratio is less than one. The social discount rate of 10 percent can be bracketed by computing net present values for rates of 5 percent and 15 percent (see rows 2 and 3). The 15 percent rate lowers the *BCR* to 0.55, and the 5 percent rate has a small positive net benefit. If 15 percent is more likely to be correct than 5 percent, the implication of this bracketing is negative. The social internal rate of return is 5.45 percent.

Difficulty in determining the national income employment gain has been noted. Alternatively, it can be postulated that the 9,000 man project labor force would not be otherwise unemployed, and the domestic wages for operation and construction are not a national income benefit. In this case the present value of the net benefit loss becomes −$173 million at a 10 percent social discount rate, −$185 million at 15 percent, and −$46 million at 5 percent.

Conclusions

Within the context of the assumptions employed here, the nuclear powered agro-industrial complex utilizing desalinated seawater would be unable to be self-sufficient financially and would retard national income growth in the United Arab Republic.

Project employment has been an important U. S. policy goal. This, in turn, has been related to expectations for refugee settlement. For example, Senate Resolution 155 stated:

> Whereas the greatest bar to a long-term settlement of the differences between the Arab and Israeli people is the chronic shortage of fresh water, useful work, and an adequate food supply; . . . Resolved, That it is the sense of the Senate that the prompt design, construction, and operation of nuclear desalting plants will provide large quantities of fresh water to both Arab and Israeli territories and, thereby, will result in—(1) new jobs for the many refugees; (2) an enormous increase in the agricultural productivity of existing wastelands; (3) a broad base for cooperation between the Israeli and Arab governments . . . . [20, p. 1]

There were about 1.35 million refugees prior to the 1967 war and perhaps 1.7 million afterwards [2]. With an assumed labor participation ratio similar to Egypt's [12, p. 33], a maximum employment goal would be 510,000 man-years. With a third of this assumed as a specific goal, 57 projects identical to this design would be required. Investment capital would be $22.5 billion, and the present value of national income benefit loss (from Table 6) would be $7.4 billion.

Fried and Edlund have suggested that desalination agriculture in the Middle East is feasible if it can be assumed that crude oil is donated "at a price that would cover its production and transportation costs" [7, p. 163]. The UAR produces some oil but also has substantial imports. Simply selling the same crude oil abroad would make a greater contribution to UAR national income.

Roger Woodworth [24] estimated that efficient irrigation agriculture in the UAR would be feasible at a water price as high as 3.6 cents per thousand gallons with a 10 percent interest rate and 10.9 cents per thousand gallons with a 5 percent interest rate. Both figures are significantly below the cost of the most efficient large-scale desalination plants being designed.[7]

It is concluded here that joint production of electricity, salts, and agriculture based upon seawater desalination with either nuclear power or oil is not economically feasible in the United Arab Republic in the foreseeable future. Such production appears to require deficit financing, provide little employment, retard national income growth compared to other investment opportunities, increase the foreign exchange deficit, and require substantial capital.

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[7] A. D. K. Laird summarizes the state of the art in engineering economics in this way [23, pp. 1-5]: (1) current design plants of one to five MGD capacity may desalt water at 50 to 80 cents per 1000 gallons; (2) larger plants to be built in five to 15 years may produce water at 20 to 40 cents per 1000 gallons; (3) very large plants built after 1985 may produce water at 10 to 15 cents per 1000 gallons. Laird's estimates are apparently in 1970 dollars with a 5 percent interest rate. Similar views are expressed in [22]. Juxtaposing Woodworth's agricultural analysis with Laird's desalting estimates suggests financial feasibility is at least 15 years away and positive project net benefits are further into the future. But this juxtaposition of Laird-Woodworth estimates is partially misleading since any large-scale desalination agriculture would be part of a larger project analogous to that analyzed here. Joint production of power and water is less costly than the separate production of each.

However, it is not correct to conclude that large-scale agro-industrial projects are inherently infeasible in the UAR or elsewhere in the Middle East.[8] Naiem Sherbiny [17] has suggested that a suitable project would (a) utilize indigenously profitable industries such as glass and glass products, paper products, pesticides, herbicides, fertilizers, clothing, and processing of agricultural products; (b) produce agricultural commodities for import substitution and export such as grains, fruits, and vegetables; and (c) use oil and/or hydropower as energy sources and ground water and/or reservoirs as irrigation sources [18]. These suggestions can be contrasted with this project's design emphasis on power-intensive industry, water-efficient crops, nuclear power, and desalination.

In retrospect, the process of analysis suffers from what might be termed "problem reversal." That is, it began with a presumed solution and attempted to relate it to the problem. To the extent that these difficulties characterize other power and water development projects, it is of general interest to economists in developing and developed countries.

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[8] It would also be incorrect to conclude that desalination is infeasible in other uses now. World desalination capacity now exceeds 300 MGD [23, p. 1] and is expected to reach 1 billion gallons per day in 1975 [22, p. iii].

References

[1] Bechtel Corporation, *Middle East Energy Center Study, Preliminary Engineering Analysis and Cost Estimates*, Los Angeles, Jan. 1970.

[2] Buehrig, Edward H., *The UN and the Palestinian Refugees*, Bloomington, Indiana University Press, 1971.

[3] Chandavarkar, A. G., "Interest Rate Policies in Developing Countries," *Fin. and Dev.* 7:19–27, March 1970.

[4] Chapman, Duane, "Economic Aspects of Nuclear Desalination in the Middle East with Special Reference to the United Arab Republic," USAEC Report ORNL-4491, Oak Ridge National Laboratory, Tennessee, June 1970 and Oct. 1972.

[5] Clawson, M., H. H. Landsberg, and L. T. Alexander, *The Agricultural Potential of the Middle East*, New York, American Elsevier Publishing Co., 1971.

[6] Eisenhower, General Dwight D., "A Proposal for Our Time," *Reader's Digest* 92:75–79, June 1968.

[7] Fried, Jerome J., and Milton C. Edlund, *Desalting Technology for Middle Eastern Agriculture: An Economic Case*, New York, Praeger Publishers, Inc., 1971.

[8] Goeller, H. E., "Appraisal of Basic Chemical and Metallurgical Industries in the United Arab Republic," USAEC Report ORNL-4492, Oak Ridge National Laboratory, Tennessee, June 1970.

[9] Hansen, B., "Employment and Wages in Rural Egypt," *Am. Econ. Rev.* 59:298–313, June 1969.

[10] Little, I. M. D., and J. A. Mirrlees, *Manual of Industrial Project Analysis in Developing Countries: Social Cost Benefit Analysis*, II, Paris, Development Centre of the Organisation for Economic Cooperation and Development, 1969.

[11] McGaughey, Stephen E., and Erik Thorbecke, "Project Selection and Macroeconomic Objectives: A Methodology Applied to Peruvian Irrigation Projects," *Am. J. Agr. Econ.* 54:32–40, Feb. 1972.

[12] Mead, D. C., *Growth and Structural Change in the Egyptian Economy*, Homewood, Ill., Richard D. Irwin, Inc., 1967.

[13] NUS Corporation, *Guide for Economic Evaluation of Nuclear Reactor Plant Designs*, U. S. Atomic Energy Commission Report TID-4500, Springfield, Va., Clearinghouse for Federal Scientific and Technical Information, Jan. 1969.

[14] Robinson, Richard D., "Multinational Corporations in Middle East Economic Development with Some Reference to Agro-Industrial Complexes," USAEC Report ORNL-4485, Oak Ridge National Laboratory, Tennessee, June 1970.

[15] ———, and J. W. Allen, "Financial Analysis Meeting of Desalting Facilities in the Middle East," unpublished memorandum, Oak Ridge National Laboratory, Tennessee, Oct. 1969.

[16] Rosenberg, L. G., "Suggested Project Analysis Guidelines and Economic Criteria for Middle East Studies," unpublished memorandum, U. S. State Dept., Dec. 12, 1968.

[17] Sherbiny, N. A., "Comparative Advantage and Development Planning Under the Foreign Exchange Constraint with Special Reference to Egypt," unpublished Ph.D. thesis, University of California, Berkeley, 1969.

[18] ———, "Planning the Agro-Industrial Complex," unpublished note, Oak Ridge National Laboratory, Tennessee, Jan. 20, 1970.

[19] U. S. Congress, House of Representatives, Subcommittee on the Near East of the Committee on Foreign Affairs, *The Middle East, 1971: The Need to Strengthen the Peace*, Hearings, 92nd Cong., 1st sess., July–Oct. 1971.

[20] U. S. Congress, Senate, Committee on Foreign Relations, *Construction of Nuclear Desalting Plants in the Middle East*, Hearings, 90th Cong., 1st sess., Oct.–Nov. 1967.

[21] U. S. Dept. of State, Agency for International Development, *A.I.D. Economic Data Book: Near East and South Asia*, continuously revised.

[22] U. S. Office of Saline Water, *1969–1970 Saline Water Conversion Report*, 1970.

[23] University of California Seawater Conversion Labora-

tory, *Saline Water Conversion Research: 1971 Annual Report*, Rpt. No. 72-1, Berkeley, Jan. 1972.

[24] WOODWORTH, R. C., T. TAMURA, AND C. M. FARMER, "Analysis of Alternative Goals in Irrigation Agriculture with Special Reference to Agro-Industrial Complexes in Egypt," USAEC Report ORNL-4495, Oak Ridge National Laboratory, Tennessee, March 1971.

APPENDIX

The following relations define the basic elements of the program used in the financial and benefit-cost analyses. The variable subscript corresponds to the column number in Table 4; 1971 is year 1 (i.e., $t=1$). Nominal prices are assumed actual future prices.

1–6. Domestic capital investment (X_1), foreign capital investment (X_2), domestic operating costs (X_3), foreign operating costs (X_4), domestic sales (X_5), and export sales (X_6) are taken from [4] and are in 1969 prices.

7. Domestic tax, first repayment analysis

$$X_{7,t} = .0488 \sum_{t=1}^{7} (X_{1,t} + X_{2,t}).$$

8. Basic cost and revenue price index, 1969 = 1.00

$$X_{8,t} = (1.029)^{t+1}.$$

9. Foreign capital price index, 1969 = 1.00

$$\begin{aligned} X_{9,t} &= (1.08)^{t+1} \quad \text{for} \quad t = 1 \text{ through } 8 \\ &= (1.08 - .05(t-8))X_{9,t-1} \\ &\qquad\qquad \text{for} \quad t = 9 \text{ through } 18 \\ &= 1.029X_{9,t-1} \quad \text{for} \quad t = 19 \text{ through } 41. \end{aligned}$$

10. Actual net domestic revenues, nominal prices

$$X_{10,t} = (X_{5,t} - X_{3,t} - X_{1,t} - X_{7,t})X_{8,t}.$$

11. Actual net foreign revenues, nominal prices

$$X_{11,t} = (X_{6,t} - X_{4,t})X_{8,t} - X_{2,t}X_{9,t}.$$

12. Domestic interest earnings or charges, nominal prices

$$\begin{aligned} X_{12,t} &= .05(X_{14,t-1} + X_{10,t}) \text{ if } X_{10,t} < 0 \\ &= .05X_{14,t-1} \quad \text{if} \quad X_{10,t} \geq 0. \end{aligned}$$

13. Foreign interest earnings or charges, nominal prices

$$\begin{aligned} X_{13,t} &= .05(X_{15,t-1} + X_{11,t}) \text{ if } X_{11,t} < 0 \\ &= .05X_{15,t-1} \quad \text{if} \quad X_{11,t} \geq 0. \end{aligned}$$

14. Domestic debt or surplus at year's end, nominal prices (S represents the sum of domestic debt, interest, and revenues to be used either in the domestic or foreign account; see text.)

$$\begin{aligned} S_t &= X_{14,t-1} + X_{12,t} + X_{10,t} \\ X_{14,t} &= S_t \quad \text{if} \quad S_t \leq 0 \quad \text{or} \quad X_{15,t-1} \geq 0 \\ &= 0 \quad \text{if} \quad X_{15,t-1} < 0 \quad \text{and} \quad S_t > 0. \end{aligned}$$

15. Foreign debt or surplus at year's end, nominal prices

$$\begin{aligned} X_{15,t} &= X_{15,t-1} + X_{13,t} + X_{11,t} + .87S_t \\ &\qquad \text{if} \quad X_{15,t-1} < 0 \quad \text{and} \quad S_t > 0 \\ &= X_{15,t-1} + X_{13,t} + X_{11,t} \\ &\qquad \text{if} \quad X_{15,t-1} \geq 0 \quad \text{or} \quad S_t \leq 0. \end{aligned}$$

For the 22.9 percent value added tax case, domestic wages (X_{16}) are \$3.053 million each year from 1978 through 2007, value added (X_{17}) is $X_{16}+X_5+X_6-X_4-X_3-X_2-X_1$. The domestic tax ($X_7$) is now 0.229 X_{17}. Calculations proceed as in the previous case.

With the tax at 5 percent of gross revenues, $X_7 = .05(X_5+X_6)$.

When the foreign nuclear and electrical investment is donated and the then-official exchange rate is used, foreign capital investment (X_2) is reduced about 50 percent (see Table 1). In X_{15}, 0.87 is replaced by 1.0.

In the analysis for no interest on foreign accounts, $X_{13} = 0$.

For the benefit-cost analyses, the social benefit and cost variables are derived from the X variables as indicated in the text.

A Methodology for Investigating the Importance of Government Intervention in Farmers' Decisions*

RICHARD E. JUST

A methodology for empirical investigation of the importance of subsidies, price supports, allotments, and diversion programs in agricultural supply response is developed and applied. Inclusion of the interdependent effects of government programs for competing crops is emphasized. Since at least some aspect of the institutional arrangements governing a group of competing commodities is often modified, a substantial part of the paper is devoted to the consistent representation of differing combinations of government program provisions in a single model of supply response. Alternative modifications and interpretations of the model for dealing with highly correlated government program variables are then considered.

ESTIMATION of agricultural acreage response has become increasingly difficult with the establishment and frequent revision of the government farm commodity programs. Not only must a response model consider the variation in allotments, price supports, and diversion requirements, but the same model must at times be forced into application using time series from both before and after the establishment of a program in order to have adequate data for estimation. Furthermore, when indirect effects of government programs for competing crops are also considered, the problem of estimation becomes even more difficult since the period of investigation will often be divided according to the times of establishment or major revision of programs for a whole group of crops. In some cases, only a few years' data may be obtainable under a given set of institutional arrangements.[1] In this paper some possibilities for simultaneous analysis of data from periods with different combinations of institutional arrangements are examined.[2] First, a free market in which acreage decisions are based on decision makers' subjective expectations of prices and yields is outlined. The possible effects of taxes, subsidies, and price supports on subjective expectations are then included, and the effects of allotments and diversion requirements on the set of possible decisions are considered. Finally, the methodology is summarized and an example of application is given.

A Free Market Model

For the free-market model, decisions are assumed to depend on price and yield expectations which are in turn based on past prices and yields. Suppose s_t is an $n \times 1$ vector of economic state variables including prices and yields of interest to decision makers for period t and that decision makers form subjective distributions for those state variables immediately following their observation in period $t-1$. If only the subjective means change and all higher subjective moments are considered constant, revision of subjective knowledge is generally described by an expectations (or subjective mean) vector,[3]

$$(1) \qquad m_t = \sum_{k=0}^{\infty} a_k s_{t-k-1},$$

for some set of weights $\{a_k\}$.

On the basis of the subjective distribution of state variables, decision makers can then consider the corresponding subjective distribution of such outcomes as profits and sales associated with any resource allocation decision d_t in the set of all possible decisions D. Assuming the vector of outcomes of interest to the decision

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[1] For example, data are only available for a single year, 1954, under the institutional arrangement whereby cotton has an allotment and rice does not.

[2] As reported in a recent issue of this *Journal*, Houck and Ryan [6] initiated research on a general methodology for evaluating farm commodity program effectiveness. However, their work deals very little with the important interdependent effects of government programs since they consider only one crop.

[3] Although changes in the subjective distribution of state variables might be more generally described by including other moments, the more conventional approach which results in a classical distributed lag model is taken here for ease of exposition. A more general case is treated in Just [8].

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maker is completely determined by the observed prices, and yields in s_t and the acreage decision vector d_t, the subjective distribution of outcomes will depend only on d_t and m_t.[4] Hence, the vector of acreage decisions d_t in D which corresponds to the most preferred subjective distribution of outcomes will depend only on m_t.[5] Since the vector of acreage decisions depends only on m_t when D is fixed, the decision correspondence can be approximated as

$$d_t = \beta_0 + \beta_1 m_t + \epsilon_t \tag{2}$$

for estimation purposes where β_0 is a $p \times 1$ parameter vector, β_1 is a $p \times n$ parameter matrix, and ϵ_t is a $p \times 1$ vector of stochastic disturbances possibly arising from stochastic measurement of decisions, a randomization in the decision process, or errors of approximation by the linear decision function.[6] This paper considers the possible modifications of a decision correspondence represented by (2) that might result from government intervention. The government will be assumed to intervene in any combination of the following ways:

1. By provision of subsidies or imposition of taxes on inputs and outputs;
2. By imposition of restrictions on the use of certain inputs; and
3. By establishment of price support levels at which the government would purchase all of the commodity which could not clear the market at the resulting price.

For each case the production sector is assumed to be atomistic with each producer facing completely elastic supply and demand.

Subsidies and Taxes

Assuming that subsidy and tax levels are announced prior to the commencement of the production process and that producers are indifferent as to how much of the price paid (received) goes to (comes from) the government as opposed to other agents in the economy, subjective distributions would simply be modified by a location parameter. If all taxes and subsidies are known prior to decision making, the mean of the subjective distribution would simply be shifted by that amount so the econometric model in (2) would become

$$d_t = \beta_0 + \beta_1(m_t + s_t^*) + \epsilon_t$$

where s_t^* is the vector of known taxes and subsidies corresponding to s_t.

If on the other hand taxes and subsidies are in some way stochastic, they might be treated in the same framework as the other variables for which subjective distributions are formed. Hence, it would suffice simply to expand the dimension of the state vector s_t, the expectation vector m_t, and the associated parameter matrix β_1. However, if all subjective moments of taxes and subsidies beyond the mean are constant throughout the period for which the econometric model is intended, taxes and subsidies can simply be combined with prices. Hence, m_t could be redefined as

$$m_t = \sum_{k=0}^{\infty} a_k(s_{t-k-1} + s_{t-k-1}^{**})$$

again using the model in (2) where s_t^{**} is a vector of stochastic taxes and subsidies with a structure corresponding to s_t.

Restrictions on Input Use

Input rather than output restrictions are used to control agricultural production in order to prevent disposal of commodities after production. The input that is chosen must not be easily substitutable in production if the restriction is to have much effect. It is assumed that each firm has a fixed amount of some resource i at its disposal (e.g., tillable land in agricultural crop production) that is valuable enough in the production of some set of outputs so as to be completely used in any production plan even when restrictions are imposed on use of the in-

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[4] To see this, suppose the subjective distribution of s_t is represented by $g_s(s_t \mid m_t)$ since all moments except m_t are assumed constant and that the vector of outcomes r_t is determined by the outcome function $r_t = r(s_t, d_t)$. If the outcome function is well behaved so that both the inverse function, $s = r^{-1}(r, d)$, and the Jacobian of the transformation from s to r, $J(r, d) = \partial r^{-1}(r, d)/\partial r$, exist, then the subjective distribution of outcomes will be

$$g_r(r_t \mid d_t, m_t) = g_s[r^{-1}(r_t, d_t) \mid m_t] \mid J(r_t, d_t) \mid$$

which depends only on d_t and m_t.

[5] The subjective distribution of outcomes is commonly referred to as a prospect (see Savage [11] or Marschak and Radner [9]). The existence of personal prospects or the ability to treat decision makers as though they exist is proved under a general set of axioms in Arrow [2]. All that is additionally required for an allocative mechanism such as approximated in (2) is the ability of the decision maker to rank his personal prospects (i.e., consistent beliefs as described by Marschak and Radner).

[6] Lags in decision behavior resulting from technological or institutional forces are ignored here. If technological or institutional forces in addition to the government programs are operative, additional variables would be needed to reflect their influence on D.

put in the production of some subset of the outputs.

Imposition of a restriction on input use would have the effect of limiting the set of possible decisions D.[7] Where d_t is a real p-dimensional decision in D and p^* is the number of outputs for which resource i is possibly used as an input, d_t might be partitioned as

$$d_t = \begin{bmatrix} d_t^* \\ \text{---} \\ d_t^{**} \end{bmatrix},$$

where $d_t^* \in D^*$ is p^*-dimensional and specifies the amount of resource i used in the production of each of the p^* outputs.[8] Hence, when negative inputs are not possible, D^* can be simply described by the equation

$$\sum_{j=1}^{p^*} d_{tj}^* = D_i \tag{3}$$

where D_i represents the amount of resource i available, and d_{tj}^* is the amount of the ith resource used in the production of the jth output. If the restriction

$$d_{tk}^* \leq \bar{d}_{tk}^*$$

is placed on the use of resource i in the production of the kth output during part of the period of study and the restriction is effective, then the description of D^* would become

$$\tag{4} \begin{array}{ll} \left.\begin{array}{l} \displaystyle\sum_{\substack{k=1 \\ j\neq k}}^{p^*} d_{tk}^* = D_i - \bar{d}_{tk}^* \\ \qquad d_{tk}^* = \bar{d}_{tk}^* \end{array}\right\} & \text{for } t \in T_k^*; \\ \displaystyle\sum_{j=1}^{p^*} d_{tj}^* = D_i & \text{for } t \in T_k^{**}, \end{array}$$

where T_k^* is the period in which the restriction is imposed and T_k^{**} is the complement of T_k^* in T, the period of time for which the econometric model is intended.

Suppose $\bar{\bar{d}}_t^*$ is the set of decisions that would be made with respect to resource i in the absence of restrictions. Then (4) could be written as

$$\left.\begin{array}{l} \displaystyle\sum_{\substack{j=1 \\ j\neq k}}^{p} d_{tj}^* = D_i - \bar{d}_{tk}^* + \Delta_{tk}^* \\ \qquad d_{tk}^* = \bar{\bar{d}}_{tk}^* - \Delta_{tk}^* \end{array}\right\} \quad \text{for } t \in T,$$

where

$$\Delta_{tk}^* = \begin{cases} \bar{\bar{d}}_{tk}^* - \bar{d}_{tk}^* & \text{for } t \in T_k^*; \\ 0 & \text{for } t \in T_k^{**}. \end{cases}$$

Since Δ_{tk}^* not only represents the decrease in use of resource i in the production of output k but also the additional amount of resource i available for producing other outputs, the variation in D might be represented adequately in the econometric model by including a Δ_{tk}^* term in every equation thus obtaining

$$d_t = \beta_0 + \beta_1 m_t + \Delta_{tk}^* \tilde{\beta}_2 + \epsilon_t, \tag{5}$$

where $\tilde{\beta}_2$ is a p-dimensional parameter vector.[9] If the restriction is strictly met, the kth element of $\tilde{\beta}_2$ might be appropriately constrained ($\tilde{\beta}_{2k} = -1$). Even with the restriction effective, however, the kth element of $\tilde{\beta}_2$ might be slightly greater in absolute value than what the restriction, $\tilde{\beta}_{2k} = -1$, indicates, for example, due to indivisibilities.

In the above model, then,

$$\Delta_{tk}^* = I_{tk}(\beta_{0k} + \beta_{1k\cdot} m_t - \bar{d}_{tk}^*) \tag{6}$$

where

$$I_{tk} = \begin{cases} 1, & \text{for } t \in T_k^*; \\ 0, & \text{for } t \in T_k^{**}. \end{cases}$$

In each case the k subscript references the kth element of each of the vectors except in the case of $\beta_{1k\cdot}$ which denotes the kth row vector of β_1. Substituting (6) into (5), the resulting model is nonlinear in parameters and requires restrictions for efficient estimation.[10] If the subjective

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[7] Although one might consider the variation in restrictions through the state information vector, such a procedure is not suggested by the underlying correspondence in (2). Restrictions are known prior to decision making and cause a variation in D, the set of possible decisions. If D is varying, then the decision actually made depends on D in addition to m_t. On the other hand, if restrictions are considered as part of s_t, then one has no basis for treating data from periods both with and without allotments simultaneously since the dimension of s_t changes.

[8] The implicit assumption made here is that production functions for different enterprises are essentially independent so the amount of resource i (land) used in the production of the jth output (crop) has meaning.

[9] It may, of course be interesting to allow β_0 and β_1 to change with the establishment of restrictions in any econometric investigation, but available time series data often prevents the inclusion of extra variables that such an analysis requires.

[10] Substituting (6) in (5) we obtain

$$d_t = \beta_0 + \beta_1 m_t + I_{tk}\beta_4^* + I_{tk}\beta_5^* m_t \beta_6^* + I_{tk}\bar{\bar{d}}_{tk}^* \beta_7^* + \epsilon_t$$

distribution of s_t remains relatively constant during the period of restriction, however, it would then suffice to estimate Δ_{tk}^* as

$$\Delta_{tk}^* = b_{1k}I_{tk} + \bar{d}_{tk}^*I_{tk} \tag{7}$$

since m_t and thus $\bar{d}_{tk}^*$ would be nearly constant. With the subjective distribution of s_t nearly constant, $b_{1k}I_{tk}$ would estimate the nearly constant $\bar{d}_{tk}^*$ and, hence, Δ_{tk}^* as in (7) would estimate $\bar{d}_{tk}^* - \bar{d}_{tk}^*$. Thus, the model could be expressed as

$$d_t = \beta_0 + \beta_1 m_t + I_{tk}\beta_2 + \bar{d}_{tk}^*I_{tk}\beta_3 + \epsilon_t \tag{8}$$

where $\beta_2 = b_{1k}\tilde{\beta}_2$ and $\beta_3 = \tilde{\beta}_2$. Hence, linear methods can be used to estimate the model. Furthermore, efficiency can be attained by imposing only the simple constraint of proportionality between β_2 and β_3. If the model is comprised of a single equation, i.e., $p = 1$, then no constraints are needed for efficiency.

If the level of the restriction is also nearly constant during the relevant time interval (i.e., $\bar{d}_{tk}^* \simeq b_{2k}$), then

$$b_{1k}I_{tk}\beta_2 + \bar{d}_{tk}^*I_{tk}\beta_3 \simeq (b_{1k} + b_{2k})I_{tk}\tilde{\beta}_2. \tag{9}$$

And, if only the coefficient vector of I_{tk} is of interest and not the relative magnitudes of b_{1k} and b_{2k}, then the model in (8) can be adequately expressed as

$$d_t = \beta_0 + \beta_1 m_t + I_{tk}\beta_2^*. \tag{10}$$

where $\beta_2^* = (b_{1k} + b_{2k})\tilde{\beta}_2$. Hence, estimation is highly simplified and no constraints are needed.

Although quite restrictive assumptions have been used, the simplifications discussed here may perhaps be applicable. Input restrictions are often used to regulate an industry. For example, a usual goal of acreage allotments is the stabilization of price and production. Thus, if the goal is in some sense achieved, the subjective distribution of s_t (represented by m_t) should change relatively little during the period of restriction. Furthermore, the restriction level would also be held relatively constant if stabilization is sought, thus making (10) a model of practical applicability. Indeed, agricultural acreage allotments have been revised relatively little compared to their magnitude in recent years.

Price Supports

Price support[11] programs cannot be simply included in the model as taxes and subsidies are. In the simplest approach, price supports may be viewed as modifying the subjective distributions for prices. Assuming (a) that support prices are announced prior to the commencement of the production process and (b) that support programs are administered so as to prevent price from ever falling below the support level while being ineffective when a free-market price above the support level occurs, a decision maker's subjective distribution of the economic state in period t given by $g_s(s_t \mid m_t)$ would become[12]

$$g_s^*(s_t \mid m_t, \psi_t) = \begin{cases} 0 & \text{for } s_{2t} \ngeq \psi_t \\ \displaystyle\int_{-\infty}^{\psi_t^a} g_s(s_t \mid m_t)\,ds_{2t}^a & \\ & \text{for } s_{2t}^a = \psi_t^a,\ s_{2t}^b > \psi_t^b \\ g_s(s_t \mid m_t) & \\ & \text{for } s_{2t} \gg \psi_t. \end{cases}$$

s_t is partitioned with s_{2t} representing prices received, ψ_t is a vector of price support levels in period t corresponding to s_{2t}, and the a and b superscripts represent any sub-partition of the vectors s_{2t} and ψ_t. Since variation in the subjective distribution of s_t and, thus, the subjective distribution of outcomes no longer depends completely on m_t in (1) but also on ψ_t, the set of changing explanatory variables in the econometric model would be augmented with ψ_t. The linearization of the model might now, however, be somewhat more questionable. If the support level varied several standard deviations above and below expected price, the relative effects of the support level as opposed to free-market expectations would be very much different. However, the consequences of linearization should not be disastrous even though effectiveness varies unless the probability of effectiveness of the price support changes drastically. A support level may be effective in one period and not the next while the probability of effectiveness remains constant. Changes in support

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where $\beta_4^* = \beta_{0k}\tilde{\beta}_2$, $\beta_5^* = \beta_{1k}\cdot$, and $\beta_6^* = \beta_7^* = \tilde{\beta}_2$. This model is not only nonlinear but requires the imposition of the constraints $\beta_4^* = \beta_{0k}\beta_6^*$, $\beta_5^* = \beta_{1k}\cdot$, and $\beta_6^* = \beta_7^*$ if efficient estimators are to be obtained.

[11] Although only price support programs for outputs are specifically referred to here, the same mechanism would also carry through if minimum or maximum input price programs were of interest.

[12] Two $n \times 1$ vectors u and v are defined to have the relationship $u \gg v$ if the ith coordinates of u and v have the relationship $u_i > v_i$ for $i = 1, \cdots, n$.

levels may be well correlated with expectations and thus have a relatively constant probability of effectiveness. For example, the support levels offered for various agricultural commodities are often highly influenced by the administration's expectations of free-market price and demand. Hence, if the administration's expectations are to some degree correlated with private expectations, the decision maker's subjective probability of price support effectiveness might not vary greatly.

Voluntary Programs

For the purpose of this paper, compliance with voluntary allotment programs will be treated as exogeneous. Most voluntary programs have not been in effect long enough to allow an adequate time series treatment of compliance as a decision variable when important interdependencies of programs are also considered. With price supports treated in a linearized way, the jth equation of the model in (2) might be modified to represent full compliance when only the kth program is offered as follows:

$$\begin{aligned} d_{tj} = \beta_{0j} &+ \beta_{1j\cdot} m_t^* + \beta_{2jk} I_{tk} \\ &+ \beta_{3jk} \bar{d}_{tk}^* I_{tk} + \beta_{4jk} \psi_{tk} + \epsilon_{tj} \end{aligned}$$

where

$$m_t^* = s_t^* + \sum_{k=0}^{\infty} a_k (s_{t-k-1} + s_{t-k-1}^{**})$$

and the j subscript references the jth elements of the vectors d_t, β_0, and ϵ_t while $\beta_{1j\cdot}$ represents the jth row of β_1. If there were no compliance, then under the provisions of the programs both allotments and price supports would become ineffective hence implying the model corresponding directly to (2),[13]

$$d_{tj} = \beta_{0j} + \beta_{1j\cdot} m_t^* + \epsilon_{tj}.$$

Thus a reasonable way to deal with a voluntary program for the kth decision variable where ϕ_{tk} is the proportion of decision makers in terms of the restricted input (land) that comply (i.e., the proportion of the total amount of the input controlled by compliers) would be to use the model

$$\begin{aligned} d_{tj}^c = \phi_{tk}[\beta_{0j} &+ \beta_{1j\cdot} m_t^* + \beta_{2jk} I_{tk} \\ &+ \beta_{3jk} \bar{d}_{tk}^* I_{tk} + \beta_{4jk} \psi_{tk} + \epsilon_{tj}] \end{aligned}$$

for complier's response and the model

$$\begin{aligned} d_{tj}^n = (1 - \phi_{tk})[\beta_{0j} &+ \beta_{1j} m_t^* \\ &+ \beta_{4jk}(1 - I_{tk})\psi_{tk} + \epsilon_{tj}] \end{aligned} \tag{11}$$

for noncomplier's response.[14] The total response of the jth decision variable would then be[15]

$$\begin{aligned} d_{tj} = \beta_{0j} &+ \beta_{1j\cdot} m_t^* + \beta_{2jk} \phi_{tk} I_{tk} \\ &+ \beta_{3jk} \phi_{tk} \bar{d}_{tk}^* I_{tk} \\ &+ \beta_{4jk}(\phi_{tk} + 1 - I_{tk})\psi_{tk} + \epsilon_{tj}. \end{aligned}$$

Hence, the model for all decisions when q different possibly voluntary programs are offered may be expressed as

$$d_t = \beta_0 + \beta_1 m_t^* + \beta_2 I_t^* + \beta_3 d_t^{**} + \beta_4 \psi_t^* + \epsilon_t$$

where β_2, β_3, and β_4 are $p \times q$ matrices with elements β_{2jk}, β_{3jk}, and β_{4jk} in the jth rows and kth columns, respectively, and where the kth elements of I_t^*, $\bar{d}_t^{**}$, and ψ_t^* are given by

$$\begin{aligned} I_{tk}^* &= \phi_{tk} I_{tk}, \\ d_{tk}^{**} &= \phi_{tk} \bar{d}_{tk}^* I_{tk}, \end{aligned}$$

and

$$\psi_{tk}^* = (\phi_{tk} + 1 - I_{tk})\psi_{tk},$$

respectively.[16]

Participation in voluntary diversion programs might also be treated exogenously in a similar manner. Indeed, a good part of diversion activities are influenced by government-controlled minimum and maximum diversion levels. As administered during the 1960's the effect of the voluntary diversion programs was to reduce the effective restriction on the acreage of the crop in question. Other crops remained essentially unaffected except through the original allotment restriction since diverted acreage could not be used to produce other crops.[17]

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[13] The tax and subsidy provisions are retained for noncompliers since in practice they have not been related to allotment and price support programs.

[14] The term $\beta_{4jk}(1-I_{tk})\psi_{tk}$ enters in (11) since farmers get full price support provisions when allotments are not imposed.

[15] Of course, it would also be interesting to consider the possibility that β_{0j} and β_{1j} change with compliance when sufficient data for such an analysis are available.

[16] Although it would also be desirable to define a ϕ_{tkj} which would be the proportion of compliance with the kth program by producers of the jth crop, such data are not available on a macro level.

[17] There have been a few exceptions to this rule. For example, under the voluntary feed grain programs, safflower

Hence, for any equation of the model

$$d_{tj} = \beta_{0j} + \beta_{1j}.m_t^* + \beta_{2j}.I_t^* + \beta_{3j}.d_t^{**} + \beta_{4j}.\psi_t^* + \epsilon_{tj}, \tag{12}$$

d_t^{**} can simply be changed to d_t^j with kth element

$$d_{tk}^j = \begin{cases} d_{tj}^{**} - d_{tj}^+ & \text{for } k = j \\ d_{tk}^{**} & \text{for } k \neq j \end{cases} \tag{13}$$

where d_{tj}^+ is the diversion associated with the jth decision variable. However, one might want to investigate the possibility that some diversion of cropland might have occurred regardless of government program activities. The diversion variable might then be considered independently thus possibly indicating a coefficient considerably less than one in absolute value. If in (13)

$$d_{tk}^j = d_{tj}^{**} - b_{3j}d_{tj}^+, \tag{14}$$

where b_{3j} is supposed to be less than one, (12) would become

$$d_{tj} = \beta_{0j} + \beta_{1j}.m_t^* + \beta_{2j}.I_t^* + \beta_{3j}.d_t^{**} + \beta_{4j}.\psi_t^* + \beta_{5j}d_{tj}^+ + \epsilon_{tj}$$

where

$$\beta_{5j} = -b_{3j}\beta_{3jj}. \tag{15}$$

Diversion would then be included as a separate independent variable, and no additional constraints would be imposed in estimation.

Another possibility which must be considered since diversion levels are often constrained as a fixed percentage of the participating allotment or base, is that

$$d_{tj}^+ \simeq \bar{b}_{4j}d_t^{**} \tag{16}$$

where $\bar{b}_{4j}$ is a zero row vector except for jth element b_{4j}. When the participating allotment and diversion variables are nearly collinear as in (16) thus preventing reasonable estimation, the diversion (allotment) variable can be dropped if the coefficient for the allotment (diversion) variable is interpreted as carrying the effect of both allotment and diversion. If the relationship in (9) also holds for all k, then

$$d_t^{**} \simeq \bar{b}_2 I_t^* \tag{17}$$

for some $q \times q$ diagonal parameter matrix $\bar{b}_2$. Thus, since participation, participating allotment, and diversion are all highly correlated, any two variables can be dropped if the coefficient of the remaining variable is interpreted as indicating the effect of all three.

Hence four versions of the government program model can result depending on which combination of the assumptions in (16) and (17) is made (see Table 1). Of course, it would always be most desirable to obtain estimates of the most general model which does not confound the effects of various aspects of the programs but, unfortunately, government program data is often very highly correlated so that little or no significance can be indicated in estimation. The importance of Models 2, 3, and 4 in Table 1 then lies in the interpretation which they lead one to consider when some of the government program variables corresponding to insignificant and highly variable coefficient estimates are dropped. Although many more possibilities could be considered, spatial considerations prevent their exposition here since very similar procedures are used for their derivation. For example, additional models could be obtained if b_{3j} in (14) and (15) were constrained equal to one as in (13) or if ψ_t^* were highly correlated with I_t^*. The four alternatives presented in Table 1, however, seem to be the important alternatives in the empirical study reported below.

An Application of the Model

In an application of this model, the effects of several programs in the San Joaquin Valley of California were studied. Choice of the San Joaquin Valley helps make the application demonstrative since a large number of crops are important competitors in the area. Furthermore, crops controlled directly by all the kinds of government programs discussed above seem to be indirectly influenced by other programs. Acreages of cotton, alfalfa, barley, corn, grain sorghums, rice, and sugar beets all appear to be considerably influenced by the cotton program. Variation in the types of government programs offered for each crop during the period of investigation is summarized in Table 2.

For this model application, the only decision variables considered are the acreages of the respective crops. The state variable chosen is returns per acre (in dollars) for each of the respective crops. Although the effects of price change might be more easily studied if separate

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acreage has qualified as diverted acreage although only half the usual diversion payment has been made for land diverted to safflower production.

Table 1. Summary of the models

Item	Models			
	1	2	3	4
Constraint(s) on the model	none	$d^{+}_{tj} = \bar{b}_{4j}\, d^{**}_{t}$	$d^{**}_{t} = \bar{b}_{2}\, I^{*}_{t}$	$d^{+}_{tj} = \bar{b}_{4j}\, d^{**}_{t}$ $d^{**}_{t} = \bar{b}_{2}\, I^{*}_{t}$
Description of constraints†	none	Diversion highly correlated with participating allotment.	Participating allotment highly correlated with participation.	Diversion, participation, and participating allotment all mutually highly correlated.
Variables excluded in regression	none	d^{+}_{tj}	d^{**}_{t}	d^{+}_{tj}, d^{**}_{t}
Government Program terms included in estimation	$\beta_{2j\cdot}\, I^{*}_{t}, \beta_{3j\cdot}\, d^{**}_{t}, \beta_{4j\cdot}\, \psi^{*}_{t}, \beta_{5j}\, d^{+}_{tj}$	$\beta_{2j\cdot}\, I^{*}_{t}, \beta^{*}_{3j\cdot}\, d^{**}_{t}, \beta_{4j\cdot}\, \psi^{*}_{t}$	$\beta^{*}_{2j\cdot}\, I^{*}_{t}, \beta_{4j\cdot}\, \psi^{*}_{t}, \beta_{5j}\, d^{+}_{tj}$	$\beta^{+}_{2j\cdot}\, I^{*}_{t}, \beta_{4j\cdot}\, \psi^{*}_{t}$
Interpretation	Effects not confounded so interpretation is clear.	Participating allotment coefficient includes the effect of the participating allotment level as well as diversion. $(\beta^{*}_{3j\cdot} = \beta_{3j\cdot} + \beta_{5j}\bar{b}_{4j})$	The participation coefficient includes the effect of participation as well as the participating allotment level. $(\beta^{*}_{2j\cdot} = \beta_{2j\cdot} + \beta_{3j\cdot}\bar{b}_{2})$	The participation coefficient includes the effects of participation, the participating allotment level, and diversion $(\beta^{+}_{2j\cdot} = \beta_{2j\cdot} + \beta^{*}_{3j\cdot}\bar{b}_{2})$
Constraints needed for efficient estimation	$\beta_{2j\cdot}$ proportional to $\beta_{3j\cdot}$ (no constraint if $p = 1$).	$\beta_{2j\cdot}$ proportional to $\beta_{3j\cdot}$ except for the jth coordinate (no constraint if $p \leq 2$).	none	none

†Constraints are described in terms of correlation although the algebraic constraints imply proportionality since the more general relationships actually provide grounds for the simplifications in Models 2, 3, and 4. Proportionality relationships were used in the derivation simply for ease of exposition.

variables are included for both price and yield, ime series data are rather limited in the San Joaquin Valley relative to the large number of mportant crops. Hence, the important variaion in both prices and yields is combined in his study to conserve degrees of freedom. However, one can still usefully study the effects of price change with the resulting model if yields are held constant or assumed to change in a particular way.

The temporal distribution of lags used by decision makers in formulating subjective expectations is assumed to be geometric, i.e.,[18]

$$m_t = \theta \sum_{k=0}^{\infty} (1-\theta)^k s_{t-k-1}$$

or

$$m_t^* = s_t^* + \theta \sum_{k=0}^{\infty} (1-\theta)^k (s_{t-k-1} + s_{t-k-1}^{**}).$$

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[18] Of course, there is nothing in the methodology presented in this paper which requires the lag distribution for s_t to be geometric. Any of the common lag distributions or possibly only a simple one period lag on prices and yields could be used. If the lag distribution were any one for which complications are not added to estimation when additional nonlagged explanatory variables (the government program variables) are included, ordinary linear regression methods would suffice. The geometric lag distribution was used here because it seems somewhat more justifiable under some simple additional assumptions on the underlying model in (2) (see Just [8]).

Table 2. Summary of government programs for selected California crops, 1949–70

Crops	Subsidies	Strict Allotments	Voluntary Allotments	Price Support	Voluntary Diversion
Cotton		1950, 1954–70		1949–70	1966–70
ice		1955–70		1949–70	
lfalfa Hay					
Corn*			1961–70	1949–70	1961–70
Grain Sorghum			1961–70	1949–70	1961–70
arley			1962–66, 69, 70	1949–70	1962–66, 69, 70
ugar Beets**	1949–70				

* The corn allotments of the 1950's do not apply to California since it is not in a major corn producing area.

** Although proportionate shares (which might be handled like allotments) were established for sugar beets in 1955–60, 965, and 1966, statistics did not indicate them to be significant.

Rather than using the standard Koyck reduction (see, e.g., Griliches [5]) which can result in more variable estimates of parameters for slowly changing independent variables (such as allotments), the equations have been estimated directly in their structural form. This was accomplished by splitting the summation over state variables into observable and unobservable parts. Where t_0 is the first year for which data is available on d_t and s_t, the most general model (Model 1) might be expressed as

$$\begin{aligned} d_{tj} = \beta_{0j} + \beta_{1j}\cdot &\left[\sum_{k=t-t_0}^{\infty} \theta(1-\theta)^{k-t+t_0}(s_{t-k-1} + s_{t-k-1}^{**})\right](1-\theta)^{t-t_0} \\ &+ \beta_{1j}\cdot\left[s_t^* + \sum_{k=0}^{t-t_0-1} \theta(1-\theta)^{k}(s_{t-k-1} + s_{t-k-1}^{**})\right] \\ &+ \beta_{2j}\cdot I_t^* + \beta_{3j}\cdot d_t^{**} + \beta_{4j}\cdot\psi_t^* + \beta_{5j}d_{tj}^{+} + \epsilon_{tj}. \end{aligned}$$

Since

$$\sum_{k=t-t_0}^{\infty} \theta(1-\theta)^{k-t+t_0}(s_{t-k-1} + s_{t-k-1}^{**})$$

is completely unobservable, it can be treated as a parameter to be estimated so the model becomes

$$\begin{aligned} d_{tj} &= \beta_{0j} + \beta_{1j}^*(1-\theta)^{t-t_0} + \beta_{1j}\cdot m_t^{**} \\ &\quad + \beta_{2j}\cdot I_t^* + \beta_{3j}\cdot d_t^{**} + \beta_{4j}\cdot\psi_t^* \\ &\quad + \beta_{5j}d_{tj}^{+} + \epsilon_{tj} \end{aligned} \tag{18}$$

where

$$\beta_{1j}^* = \beta_{1j}\cdot \sum_{k=t-t_0}^{\infty} \theta(1-\theta)^{k-t+t_0}(s_{t-k-1} + s_{t-k-1}^{**})$$

and

$$m_t^{**} = s_t^* + \sum_{k=0}^{t-t_0-1} \theta(1-\theta)^{k}(s_{t-k-1} + s_{t-k-1}^{**}).$$

In the resulting model, then, β_{1j}^* represents the combined impact of all subjective knowledge held at t_0. Although this is a rather vague notion, its importance diminishes with time, i.e., as $(1-\theta)^{t-t_0}$ approaches zero. For example, if t_0 were 1949 as in this study and one were interested in the effects of current policy, then β_{1j}^* could be of little importance if θ were not close to zero since $(1-\theta)^{t-t_0}$ would be very small. On the other hand, m_t^{**}, a vector indicating the component of decision makers' subjective means due to state variable observations since t_0, is of increasing importance. With sufficient passage of time, m_t^{**} becomes essentially equal to the vector of decision makers' subjective state variable means since the contribution of periods prior to t_0 approaches zero with $(1-\theta)^{t-t_0}$. In the short run, m_t^{**} accounts for $[1-(1-\theta)^{t-t_0+1}]\times 100$ percent of the weighting in decision makers' subjective means.

d_{tj} = acreage used in the production of the jth crop,
$(1-\theta)^{t-t_0}$ = the influence of prices, yields, and stochastic subsidies and taxes observed prior to t_0,
m_t^{**} = the influence of prices, yields, stochastic and nonstochastic subsidies and taxes observed since t_0,
s_t = vector of prices and yields (or in this case, prices times yields) observed in period t,
s_t^* = vector of nonstochastic (announced before decisions are made) subsidies and taxes for period t,[19]
s_t^{**} = vector of stochastic (not known until after decisions are made) subsidies and taxes for period t,[20]
I_t^* = vector of allotment indicators (1 if allotment, 0 if no allotment) times the respective rate of participation (acreage on participating farms divided by the total allotment),
d_t^{**} = vector of allotment levels times the respective rate of participation,
ψ_t^* = vector of price support levels times the respective rate of participation

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[19] Since nonstochastic subsidies and taxes are not imposed for the commodities considered here, s_t^* is identically zero in this application.

[20] For the example used here, the stochastic subsidies and taxes vector is also zero except for the coordinate corresponding to sugar beets where the average government payment per acre to sugar beet growers has been included.

when respective allotments are established; vector of price support levels when respective allotments are not established,

d_{tj}^{+} = acreage diverted under the government program for crop j, and

ϵ_{tj} = stochastic disturbance in the jth acreage decision.

ϵ_{tj} is assumed here to be normally distributed with $E(\epsilon_{tj})=0$ and $E(\epsilon_{t_1 j}\epsilon_{t_2 j})=0$ for $t_1 \neq t_2$. Contemporaneous correlation is ignored since only single equation maximum likelihood estimators are used. Efficiency is thus not a property of the estimators used here unless one assumes $E(\epsilon_t \epsilon_t')$ to be diagonal. Even then efficiency would still not be attained for those equations requiring constraints.[21] Consistency can be claimed by the following procedure, however.

Since θ is the only parameter which enters (18) nonlinearly, maximum likelihood estimates were found by conditionally maximizing the likelihood function with respect to all other parameters via a standard regression program for a variety of values of θ.[22] The globally maximizing estimates were then found through a Fibonacci search since all the conditionally maximized likelihood functions demonstrated local concavity near their maximum.[23]

For the equation of each crop except alfalfa, 22 years of time series data from 1949 to 1970 were used to estimate the model. In the case of alfalfa, only 21 years of data were used since a lagged dependent variable was included to allow for the perennial nature of alfalfa. Regression results conditional on the indicated maximum likelihood estimates of θ are given in Table 3. In each case, the argument of the variables indicates the crop to which the variable pertains.[24] Although standard errors are reported to give some indication of significance, they only apply asymptotically (because θ is only estimated consistently) when $E(\epsilon_{t_1 j}\epsilon_{t_2 j})=0$ for $t_1 \neq t_2$. The Durbin-Watson (D) statistic is also reported since it gives some indication as to whether the assumption $E(\epsilon_{t_1 j}\epsilon_{t_2 j})=0$ for $t_1 \neq t_2$ is satisfied in the equations for crops other than alfalfa. Of course, one would not expect the assumption to be satisfied in the alfalfa equation where a lagged dependent variable was used.

In determining the final government program model to be used in each equation, the following steps were taken. For each crop in the model, an acreage equation was first estimated in its most general form corresponding to Model 1. Then, in cases where the correlation of variables appeared high enough to prevent the significance of estimates, the assumptions in (16) and (17) were considered and Model 2, 3, or 4 was estimated. Price support variables were then dropped in cases where they appeared to be of no importance and in one case, the sugar beet equation, the participation variable I_t^* for corn was dropped because it appeared to have no effect on sugar beet acreage response.

As is evident in Table 3, different government programs were not always handled according to the same model in the same equation. For example, in the equation for grain sorghum, feed grain program variables were included according to Model 4 while cotton program variables were included according to Model 2. No additional difficulties arise from following this procedure as long as coefficients of the different program variables were interpreted according to their respective models. If constraints had been imposed from equation to equation in estimation, however, it would have been necessary to consider each program according to the same model from equation to equation al-

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[21] If a lag distribution which results in a linear model had been assumed, then all ordinary regression estimators would be unbiased. Efficiency would also be attained in those equations where constraints are not needed when $E(\epsilon_t\epsilon_t')$ is diagonal. Due to the nature of the lag distribution chosen here, however, a nonlinear parameter enters each equation of the system thus suggesting a multidimensional maximum likelihood search or multivariate nonlinear regression for simultaneous estimation when θ is allowed to vary from equation to equation. Improved estimates could be obtained, however, by applying a two step method whereby the geometric parameters could first be estimated by the single equation method described in this paper and then taken as given in simultaneously estimating all other parameters in the system. Contemporaneous and serial correlation of disturbances could then also be considered by employing methods such as those developed by Zellner [12] and Parks [10].

[22] The essential details of the estimation method outlined here can be found in Dhrymes [3, 4].

[23] The well-known Fibonacci search method is the optimal one-dimensional search method in the sense that it minimizes the maximum possible interval of uncertainty in which the maximum of a unimodal function can lie after a fixed number of points on the function have been evaluated. For a detailed discussion of the method see Aoki [1] or Howard [7].

[24] Crops are denoted as follows: COT = cotton, RIC rice, ALF = alfalfa hay, COR = corn for grain, GS = grain sorghum for grain, BAR = barley, and SB = sugar beets.

Table 3. Regression results for acreage response in the San Joaquin Valley, 1949–70

Estimated Equation	θ	R^2	$\bar{R}^2$	D
$d_t(\mathrm{COT}) = 1{,}080{,}300 + 336.36\, m_t^{**}(\mathrm{COT}) - 1{,}072{,}500\, I_t^*(\mathrm{COT}) + .74067\, d_t^{**}(\mathrm{COT})$ (87,900) (186.61) (134,300) (.17988) $+ 379.86\, \psi_t^*(\mathrm{COT}) - .62416\, d_t^+(\mathrm{COT}) - 173{,}610\, (1-\theta)^{t-t_o}$ (508.31) (.36809) (88,440)	.876	.97	.96	2.17
$d_t(\mathrm{RIC}) = 52{,}808 - 55.292\, m_t^{**}(\mathrm{COT}) + 47.358\, m_t^{**}(\mathrm{RIC}) + 64{,}294\, I_t^*(\mathrm{COT})$ (13,317) (33.942) (46.798) (34,458) $- 92{,}037\, I_t^*(\mathrm{RIC}) - .01815\, d_t^{**}(\mathrm{COT}) + .80205\, d_t^{**}(\mathrm{RIC}) - 18{,}802\, (1-\theta)^{t-t_o}$ (16,697) (.03927) (.25531) (15,440)	.994	.83	.74	1.90
$d_t(\mathrm{ALF}) = 262{,}720 + 704.51\, m_t^{**}(\mathrm{ALF}) + 105{,}300\, I_t^*(\mathrm{COT}) + .25528\, d_{t-1}(\mathrm{ALF})$ (78,077) (226.53) (23,450) (.14591) $- 6{,}516{,}600\, (1-\theta)^{t-t_o}$ (4,943,400)	.994	.90	.87	1.46
$d_t(\mathrm{COR}) = -249{,}050 + 2{,}649.0\, m_t^{**}(\mathrm{COR}) + 55{,}913\, I_t^*(\mathrm{COT}) - 41{,}949\, I_t^*(\mathrm{COR\text{-}GS})$ (51,720) (334.9) (11,562) (21,803) $+ 30{,}472\, \psi_t^*(\mathrm{COR}) + 220{,}960\, (1-\theta)^{t-t_o}$ (14,389) (35,940)	.524	.92	.89	2.09
$d_t(\mathrm{GS}) = -82{,}601 + 3{,}805.8\, m_t^{**}(\mathrm{GS}) + 73{,}057\, I_t^*(\mathrm{COT}) - 31{,}880\, I_t^*(\mathrm{COR\text{-}GS})$ (211,046) (2,617.1) (37,419) (18,227) $- .05611\, d_t^{**}(\mathrm{COT}) - 234.54\, \psi_t^*(\mathrm{COT}) + 31{,}705\, \psi_t^*(\mathrm{GS}) + 59{,}640\, (1-\theta)^{t-t_o}$ (.05165) (128.15) (12,342) (202,490)	.071	.97	.95	2.99
$d_t(\mathrm{BAR}) = 28{,}450{,}052 - 40{,}890\, m_t^{**}(\mathrm{COT}) - 249{,}420\, m_t^{**}(\mathrm{ALF}) + 332{,}500\, m_t^{**}(\mathrm{BAR})$ (10,364,074) (16,131) (125,700) (201,530) $+ 186{,}260\, I_t^*(\mathrm{COT}) - 155{,}320\, I_t^*(\mathrm{BAR}) - 27{,}891{,}000\, (1-\theta)^{t-t_o}$ (37,030) (60,350) (10,373,000)	.006	.88	.83	1.76
$d_t(\mathrm{SB}) = 66{,}517 - 1{,}170.7\, m_t^{**}(\mathrm{COR}) + 736.24\, m_t^{**}(\mathrm{SB}) + 48{,}555\, I_t^*(\mathrm{COT})$ (40,650) (341.8) (133.48) (44,643) $- .08823\, d_t^{**}(\mathrm{COT}) - 66{,}084\, \psi_t^*(\mathrm{COR}) + 57{,}054\, (1-\theta)^{t-t_o}$ (.05746) (10,655) (33,798)	.735	.91	.87	2.19

though not necessarily from program to program.[25]

Appraisal of the Results

The government program model discussed here seems to have given reasonable results in almost every case for the allotment and price-support variables. For crops where CCC acquisitions have been negligible and production has not been controlled by voluntary allotments, price-support levels could not be shown of significance (e.g., rice and barley). For crops controlled by voluntary allotments, price supports were sometimes important even when CCC acquisitions were negligible because sizable direct support payments were made to compliers (e.g., corn and sorghum).

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[25] Actually, if constraints were to be imposed in estimation of the equations in the form presented in Table 3, only the constraint of proportionality between the coefficients for $I_t^*(COT)$ and $d_t^{**}(COT)$ would be needed among the equations for cotton, rice, grain sorghum, and sugar beets. All other equations use only a one variable allotment and diversion formulation which requires no constraints from equation to equation. However, if constraints were imposed over all equations, reasonable estimates of the other equations could probably be obtained with both cotton allotment variables included.

The allotment variables also performed well for the crops controlled by strict allotments (allotments with marketing quotas). For both cotton and rice, quite significant estimates seemed to be obtained for the coefficient of d_t^{**}. In several cases, both cotton allotment variables (I_t^* and d_t^{**}) seemed to perform well in the equations for other crops also. Although some problems were encountered with the two allotment variable formulation due to high correlation of the two variables in other cases, the reduction to one allotment variable (I_t^*) as indicated in Models 3 and 4 was effective in alleviating such difficulties. Indeed, this simplification of the model is designed for application in exactly the circumstances where the correlation of the two variables is high, i.e., when allotments have been changing little. For the feed grains, where only the single allotment variable formulation seemed to perform reasonably, total allotment (or base) was essentially constant throughout the restricted period. Hence, the resulting estimate of the coefficient $\beta_{2j.}^+$ in each case must be interpreted as an estimate of the effect of both I_t^* and d_t^{**} as indicated in Table 1. Unfortunately, little can be said about the possible effects of a change in allotment level on the basis of the results. When only the one allotment variable formulation is used, information is only gained on the possible effects of establishing or abolishing the program as it was administered—not on the effects of changing the program.

The effects of the diversion variables could also not be isolated in most cases. At least for the feed grains program, the effect of diverted acreage is probably carried in the allotment participation variables as would be the case when both (16) and (17) are satisfied. Since minimum and maximum diversion restrictions have been placed on complying farms, participation and diversion have been highly correlated. Hence, the resulting estimate of the coefficient for I_t^* must be interpreted as an estimate of the effect of the diversion provisions as well as the effect of allotment participation as indicated in Table 1. Apparently the organization of past programs is then responsible for preventing the econometric isolation of the effects of participation and diversion in many cases. Perhaps a better approach in the case of diversion might have been to restrict the coefficient of diversion in some way on theoretical grounds such as would be indicated by (13).

Conclusions

Although many studies have considered the interdependencies of supply associated with price and yield variation when evaluating farm program effectiveness, few have considered the interdependencies of government programs in supply response. This paper has attempted to demonstrate a systematic approach for the investigation of government program interdependencies in a multi-crop environment regulated by a variety of government programs. The more detailed knowledge of the interdependent relationship of the programs that this approach can give is of obvious importance in any economic analysis of agricultural policy. For example, it is impossible to make adequate predictions of future crop production if possible changes in government programs for competing crops are not considered. In the case of feed grains in the San Joaquin Valley, production projections appear to depend very heavily on the continuation of the cotton program as well as the feed grain program. The equations in Table 3 indicate that if cotton allotments had been completely dropped, feed grain acreage would have dropped by nearly 30 percent from 1970 levels if other factors were unchanged. Also, the impact of establishing or abolishing an allotment program cannot be adequately evaluated unless the effects on all competing crops are considered. These effects would likely be very important in the cotton program in the San Joaquin Valley since the empirical results indicate cotton allotments to be a dominant force in the acreage response of all the crops considered in Table 3—even those regulated directly by other programs.[26]

Finally, the complete structural knowledge resulting from this kind of analysis should be of considerable importance in evaluating variation in the welfare effects of a farm program that can or has occurred with variation in programs for competing commodities. Even though the importance of a particular program of interest in other commodity markets is often considered, government program welfare analyses too often have been designed to consider the impact of only a single program and have thus tended to neglect the variation in effects due to other programs in other markets. These welfare considerations should definitely be made when major revisions in other programs are pending and can only be made when a more complete interdependent structure of the government programs is estimated.

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[26] Although, for rice and grain sorghum, neither of the two cotton allotment variables appears highly significant, much more importance is indicated when only one of the variables is introduced separately as in Models 3 or 4.

References

[1] AOKI, M., *Optimization of Stochastic Systems*, New York, Academic Press, 1967.

[2] ARROW, KENNETH J., *Essays in the Theory of Risk-bearing*, Chicago, Markham Publishing Co., 1971.

[3] DHRYMES, P. J., "On the Treatment of Certain Recurrent Nonlinearities in Regression Analysis," *Southern Econ. J.* 33:187–196, Oct. 1966.

[4] ——, *Distributed Lags: Problems of Estimation and Formulation*, San Francisco, Holden-Day, 1971.

[5] GRILICHES, Z., "Distributed Lags: A Survey," *Econometrica* 35:16–49, Jan. 1967.

[6] HOUCK, J. P., AND M. E. RYAN, "Supply Analysis for Corn in the United States: The Impact of Changing Government Programs," *Am. J. Agr. Econ.* 54:184–191, May 1972.

[7] HOWARD, R., *Dynamic Programming and Markov Processes*, Cambridge, M. I. T. Press, and New York, John Wiley and Sons, Inc., 1960.

[8] JUST, R. E., "Econometric Analysis of Production Decisions with Government Intervention: The Case of the California Field Crops," unpublished Ph.D. thesis, University of California, Berkeley, 1972.

[9] MARSCHAK, JACOB, AND ROY RADNER, *Economic Theory of Teams*, New Haven, Yale University Press, 1972.

[10] PARKS, R. W., "Efficient Estimation of a System of Regression Equations when Disturbances Are Both Serially and Contemporaneously Correlated," *J. Am. Stat. Assoc.* 62:500–509, June 1967.

[11] SAVAGE, L. J., *The Foundations of Statistics*, New York, John Wiley and Sons, Inc., 1954.

[12] ZELLNER, A., "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias," *J. Am. Stat. Assoc.* 57:348–368, June 1962.

Short Articles and Notes

The *Journal* as a Reference Source—1959–1968*

ROBERT M. FINLEY AND RICHARD B. BARGER

Journal references were examined for the period 1959 to 1968. The extent that certain articles and authors were cited was a major consideration. Particularly interesting were comparisons of articles and references in the regular issues and the December issue; the 38 authors most frequently cited; and AAEA "Prize Winners" as references.

NOT only is title dispersion greater in agricultural economics than in the sciences and basic social sciences, but also "research . . . is published primarily in monographs or bulletins, rather than in journals" [5]. Although most will concede that the research or professional journal is our most prestigious medium,[1] less than 8 percent of our publications were published therein [5].

The *American Journal of Agricultural Economics* (formerly the *Journal of Farm Economics*),[2] the official journal in this field, is one of the largest compilations to be found anywhere of current information and data about the discipline and related areas. Here the profession writes and reads what others have written.

Editorial selection standards are high, and space is limited. This should indicate that the contents of the *AJAE* (*JFE*) are of fairly uniform high quality, readability, interest, and value. If this is not the case, the articles have no business taking valuable space from more deserving papers. Members assume (and dues-paying members have the right to expect) that what is printed must be the best of what is submitted—the best written and researched articles dealing with topics in which the readers have both an interest and a need to know—consistent with existing editorial policy.

For the period 1959 through 1968, the *Journal* consisted annually of over 1,400 pages of papers on topics as varied as the interests of the readers. Surveying the *Journal's* index for a few consecutive years should yield the researcher much relevant information on a particular topic in agricultural economics. In fact, it would be quite surprising if the writers of this *Journal* did *not* use it for the valuable reference it should be. Not only would it be surprising, it would also be disappointing.

The question arises, "Is the information appearing in the *Journal* used to further someone else's research? And is the material published in the *Journal* ever reused?" It is, of course, impossible to tell how much of what one reads is mentally retained for later use in one form or another. An item written in an individual's own words may appear to be original, if the source is not acknowledged. Yet there is a way in which *some* of this "reuse" of material can be evaluated—it can be accomplished simply by looking at listings in footnotes and bibliographies. This method will not give a complete listing of material used but will give as much as the various authors were willing or able to set down in writing.

Perhaps the most likely place to find references to a particular source is the source itself. This is surely no less true of this *Journal* than elsewhere. Members should, for the most part, know what has been written here—not only be familiar with the material covered, but also aware of the varying treatments given a sub-

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[1] Publications in professional refereed journals are necessary conditions for membership in most graduate faculties and other academic advancements. These publications have been called the "hard currency" of any profession (we acknowledge J. C. Headley for this succinct analogy). If journal publication is the "hardest" of currency, then it follows that other publications have descending levels of hardness perhaps ending with the softest—the undated, unsigned department or division newsletter.

[2] Hereafter referred to as the *AJAE* (*JFE*), or the *Journal*.

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Table 1. Number of articles and references in the *AJAE* (*JFE*), 1959–1968

	Articles	References—Authors Named	References—No Authors Named	References—Total	References—Average Per Article
Regular Issues	950	6,890 (81%)*	1,622 (19%)	8,512	8.96
December Issues	914	3,679 (77%)	1,081 (23%)	4,760	5.21
Total	1,864	10,569 (80%)	2,703 (20%)	13,272	7.12

* Percentage figures refer to percent of Total Number of References.

ject by different authors—so there will be no unnecessary duplication of effort. In fact, a prime requisite of any would-be author is to study what has been previously written on his topic and particularly so in the publication for which his material is intended.

Hence it might be expected that material published in the *Journal* be used as reference matter for future *Journal* articles. Since most *Journal* authors are also *Journal* readers, perhaps it would not be assuming too much to say that more references might be made to the *Journal* in the *Journal* than anywhere else. If this is the case, then to find references to the *AJAE* (*JFE*), it is adequate to look at the *AJAE* (*JFE*). That is precisely the point of this paper: to take a critical look at this journal to determine the source value of its articles.

The method chosen was a simple, if dreary one. All the material that appeared in the *Journal* during the 10-year period 1959 to 1968 was surveyed; this includes articles, notes, viewpoints, communications, solicited and contributed papers, discussions, proceedings and meeting minutes, indexes, footnotes, and bibliographical entries.

Problems involved in the effort were compounded by the inclusion of Proceedings papers in May and December, by different editorial policies which change (or purport to change) the makeup of the *Journal*, by widely varying procedures in the actual referencing of material from author to author, and, of course, by the sheer bulk of the material involved. Also, a set of definitions had to be developed to allow the simplified presentation in this paper of some

Table 2. Number of times individual references were cited in the *AJAE* (*JFE*), 1959–1968*

No. of Times Cited	Regular Issues			December Issues		
	References—Authors Named	References—No Authors Named	Total	References—Authors Named	References—No Authors Named	Total
1	4,171	1,357	5,528	2,738	924	3,662
2	514	70	584	269	36	305
3	165	20	185	64	14	78
4	67	9	76	31	6	37
5	49	2	51	7	2	9
6	25	2	27	3	0	3
7	19	1	20	2	0	2
8	6	0	6	0	0	0
9	4	0	4	1	1	2
10	7	0	7	0	0	0
11	4	0	4	1	0	1
12	1	0	1	0	0	0
13	2	0	2	0	0	0
14	2	0	2	0	0	0
15	3	0	3	0	0	0
16	1	0	1	0	0	0
17	0	0	0	0	0	0
18	2	0	2	0	0	0
19	1	0	1	0	0	0
20	1	0	1	0	0	0
Total Different References	5,044	1,461	6,505	3,116	983	4,099
Total Citations	6,890	1,622	8,512	3,679	1,081	4,760

* Includes both references with authors named and references for which no authors were named.

rather specific concepts. These definitions are available from the senior author upon request.

The scope of the study—the number of items surveyed—is shown in Table 1. The 1,864 articles were almost evenly divided among the regular issues and the December issues. The 40 regular issues contained 950 articles while the 10 December issues had 914. The difference between regular issues and December issues in average references per article (nine vs. five) can mostly be attributed to the differences in article lengths. It is interesting to note that 20 percent of the 13,272 references did not have authors named.

Number of references cited a given number of times is set forth in Table 2. For example, regular issues had 5,528 references cited only once each and contained one reference cited 20 times during the period. This breakdown is also given for December issues.[3]

Of note are the several references with no authors named which were cited numerous times during the period of the study. Also interesting is the number of references (with authors named) which individually were cited many times indicating that at least some references were thought to be important enough to be used and reused over the years.

The two totals at the bottom of Table 2 indicate the total number of different references in each category which were cited (again, these totals are *not* cumulative) and the total number of citations made. This is found simply by multiplying the number of references cited by the number of times cited. This line, of course, could accumulate to a grand total—the total number of reference citations made in separate articles. (See Table 1.)[4]

The number of times individual authors were cited in *AJAE* (*JFE*) references is shown in Table 3. That three authors were cited in references over 100 times each is noteworthy. Again these figures are not cumulative for much the same reason as given for the figures in Table 2.[5]

Table 3. Number of times individual authors were cited as an *AJAE* (*JFE*) reference, 1959–1968*

No. of Times Cited	Regular Issues	December Issues
1	1,913	1,337
2	427	257
3	168	109
4	102	56
5	62	31
6	46	28
7	37	11
8	30	9
9	14	5
10	13	11
11	13	4
12	5	3
13	4	4
14	7	2
15	3	2
16	8	0
17	2	3
18	3	0
19	4	5
20	4	3
21	3	3
22	3	1
23	0	0
24	3	0
25	3	0
26	1	0
27	2	0
28	0	0
29	2	0
30	0	1
31	0	0
32	1	0
33	1	0
38	1	0
40	1	1
41	1	0
43	1	0
45	0	1
48	1	0
54	0	1
72	1	0
109	1	0
114	1	0
116	1	0

* The totals in this table are different from those of succeeding tables due to the method of tabulation: here, references which had more than one author were tabulated *only* for the first author, alphabetically.

Table 4 shows the number of *Journal* articles

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[3] No grand total is available for this table due to the method of tabulation. Summing the two total columns would misstate the grand total for any given "number of times cited" by a number of references which were cited in *both* regular and December issues. For example, if the reference that was cited 20 times in regular issues also happened to be cited three times in December issues, a grand total column would have to indicate that one reference was cited 23 times. Unfortunately, merely adding the two "total" columns together would misstate this by indicating one article being cited a grand total of 20 times and no articles being cited 23 times.

[4] It is important to remember that this figure does not account for *each time* every reference was used, but only the *number of times* it was used in different articles.

[5] If, for example, the author cited 43 times in regular issues was also the one cited 45 times in December issues, the total number of times he was cited would be considerably different than a simple "adding up" of the figures in each line. Totals in Table 3 differ from those in succeeding tables due to the method of tabulation: in Table 3, references which had more than one author (multiple-author references) were tabulated only for the first author, alphabetically.

Table 4. Number of regular and December references which were originally *AJAE* (*JFE*) articles in the year indicated

Year	Number of Citations in Regular Issues		Number of Citations in December Issues		Total
	References: Authors Named	References: No Author Named	References: Authors Named	References: No Author Named	
No Date	4	0	19	0	23
1968	0	0	0	0	0
1967	25	0	7	0	32
1966	45	2	16	1	64
1965	58	0	31	0	89
1964	36	2	27	1	66
1963	39	0	33	2	74
1962	41	3	23	0	67
1961	53	3	32	2	90
1960	64	0	22	1	87
1959	63	1	28	3	95
1958	51	2	22	0	75
1957	44	3	18	2	67
1956	21	0	13	1	35
1955	24	1	6	0	31
1954	14	1	10	1	26
1953	8	1	1	1	11
1952	10	0	1	0	11
1951	8	0	5	1	14
1950	7	0	1	0	8
1949	8	0	4	0	12
1948	4	0	5	0	9
1947	6	0	0	0	6
1946	3	0	1	0	4
1945	4	0	2	0	6
1944	3	0	2	1	6
1943	0	0	2	0	2
1942	1	0	2	0	3
1941	4	0	0	0	4
1940	2	0	1	0	3
1939	2	1	5	0	8
1938	2	0	3	0	5
1937	2	0	1	0	3
1936	1	0	0	0	1
1935	1	0	0	0	1
1934	2	0	0	0	2
1933	2	0	1	0	3
1932	0	0	0	0	0
1931	0	0	0	0	0
1930	0	0	0	0	0
1929	2	0	1	0	3
1928	0	0	1	0	1
1927	0	0	0	0	0
1926	0	0	3	0	3
1925	0	0	1	0	1
1924	2	0	0	0	2
1923	0	0	0	0	0
1922	0	0	2	0	2
1921	0	0	1	0	1
1920	0	0	0	0	0
1919	0	0	1	0	1

Table 5. Comparison of *AJAE* (*JFE*) articles available for reference with the number of references actually made, 1959–1967

Year*	Number of References to Journal Articles	Total Articles for the Year (Excluding Misc.)	Minimum Number of Articles Not Used**	Minimum Percentage of Articles Not Used**
1967	32	183	151	83%
1966	64	203	139	68%
1965	89	168	79	47%
1964	66	167	101	60%
1963	74	207	133	64%
1962	67	198	131	66%
1961	90	190	100	53%
1960	87	173	86	50%
1959	95	175	80	46%
Total	664	1,664	1,000	60%

* 1968 omitted since 1968 articles had little chance to be used (and were not).

** The same article could have been used as a reference more than one time. If this happened, then in that particular year *more* articles (than stated in the table) were *not* used.

cited as references during the 10-year period and the year they originally appeared in the *Journal*. Included are 23 items (19 of which were in the December issues) which had no date of original publication listed in the reference. Three further things may be worth noting. *Journal* items written within the most recent 10 or 11 years are those used most often as references. This is perhaps true because the information is more current but might also be true because they are better remembered, being more recent. Still, there were a considerable number of references from many years ago (one as far back as 1919), indicating either that there are some "classics" which are time-honored or that the *Journal* is still a good place to go for data or information of historical value. Perhaps the most unusual aspect of the table is the large number of references with no authors named. Reasons might be twofold: (1) some items cited have no author listed, such as "the inside front cover" or general items listed in the preface pages; and (2) in other cases, poor referencing might be suspected.

A natural offshoot is found in Table 5, a comparison of the number of *Journal* articles available for reference with the number of references actually made, 1959 to 1967. The year 1968 was omitted since 1968 articles had little chance to be used and were not. During the nine-year period 1,664 articles appeared in the *Journal* (excluding miscellaneous items), and 664 references were made to these articles. It would not be correct to say 664 articles were referred to, for it is entirely possible that the same article could have been cited as a reference more than one time. In other words, the *minimum* number of articles *not* used was 1,000, or 60 percent of the total articles available.[6] This outcome could be anticipated to a degree.

Thirty-eight authors most cited as references in *AJAE* (*JFE*) articles were given a more detailed study than was possible for authors cited fewer times. Table 6 lists these 38 authors according to the number of times each was cited as a reference. The "total" column includes all times the author referred to himself. It also included *all* items co-authored with others of

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[6] The reason that this is the *minimum* number not used is as follows: if any article was used as a reference more than one time, then *more* articles (than stated in the table) were *not* cited. Thus, if all 664 references to *Journal* articles had been to *one* article written in 1959, the actual number of articles not used would be 1,663.

Table 6. The 38 authors most cited as references in *AJAE* (*JFE*) articles, 1959–1968

	Number of Times Author Used as a Reference*	Number of Times Author Cited by the "Top 38"**	Number of Times Author Cited Others of "Top 38"***	Frequency of Reference to Self***
Earl O. Heady	194	23	9	17
Theodore W. Schultz	159	29	12	23
Zvi Griliches	135	17	19	18
Marc Nerlove	80	22	5	0
Willard W. Cochrane	78	16	5	6
Vernon W. Ruttan	78	7	46	21
D. Gale Johnson	62	11	7	3
Glenn L. Johnson	57	4	0	0
George J. Stigler	56	5	—	—
George E. Brandow	55	5	4	3
Gerald W. Dean	54	7	4	5
Karl A. Fox	52	6	23	20
Harold O. Carter	48	4	12	7
Dale E. Hathaway	46	6	11	5
George G. Judge	46	5	5	6
Kenneth E. Boulding	44	6	—	—
Siegfried von Ciriacy-Wantrup	44	7	2	12
Albert N. Halter	43	4	7	5
Harold F. Breimyer	42	5	15	11
Charles E. Bishop	41	6	8	3
Frederick V. Waugh	40	2	7	0
William H. Nicholls	39	3	0	3
John D. Black	38	11	—	—
Raymond G. Bressler, Jr.	38	2	0	2
Robert M. Solow	36	4	—	—
Richard H. Day	35	2	14	8
Marion Clawson	33	2	3	3
Henri Theil	33	7	—	—
Wilfred Candler	31	4	4	3
Maurice M. Kelso	30	5	1	0
Joe S. Bain	29	0	—	—
Robert Dorfman	27	5	—	—
Emery N. Castle	26	0	25	12
Richard J. Foote	26	2	0	0
Milton Friedman	26	5	—	—
Alfred Marshall	25	8	—	—
Wayne A. Fuller	23	0	9	7
James T. Bonnen	22	6	6	3

* This includes all references to self. It also includes *all* items co-authored with others of the "Top 38," whether or not the listed author was first, alphabetically. All other co-authored references were tabulated for the listed author *only* if he was first, alphabetically.

** This is number of times he was cited by those of the "Top 38" who wrote *Journal* articles, 1959–1968. This excludes references to self. See Table 8.

*** If he wrote a *Journal* article, 1959–1968, "—" indicates that the author had nothing published in the *Journal* during this period. See Table 8.

the "Top 38."[7] The number of citations ranges from a high of 194 for Earl O. Heady to 22 for James T. Bonnen.[8]

The number of citations "Top 38" authors (who wrote *Journal* articles during this period) made to one another was observed. The second column of Table 6 shows the number of times the author listed was cited by others of the "Top 38" excluding himself. Schultz was cited the most—29 times. The third column shows the parallel—the number of times the author listed cited others of the "Top 38" (if he wrote a *Journal* article during this period). Ruttan made more citations to others in the "Top 38" than did anyone else in this group.

The 15 (16 in the case of December) authors from the "Top 38" who wrote the most *Journal* articles during the 10-year period are listed in

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[7] Only for these 38 authors was a complete cross-tabulation made, regardless of who was first author, alphabetically. All other co-authored references were tabulated for the listed author only if he was first alphabetically (the same as Table 3).

[8] Unfortunately, this figure could be subject to some misinterpretation again due to the method of tabulation. A few of the authors at the end of this list may actually have been cited fewer times than some others who do not appear on it. This is because Table 6 was compiled so as to favor authors who were frequently cited in either regular issues *or* December issues, as opposed to those who were cited a moderate number of times in both regular and December issues, but perhaps more in total.

Table 7. The number of articles authored by each follows in parentheses. Comparison of the number of times these men wrote in regular vs. December issues may be important. The fact that several of these authors are not included on both lists certainly could indicate that the editorial committee and the chairmen of Proceedings committees may differ in their opinion of the worth of the contribution a given individual might make.[9] It is important to realize that this table shows only the frequency of *Journal* publication by the 38 authors most often cited as references and since the focus was on the reference authors, not on the authors of the *Journal* itself, Table 7 was the only place any examination of *Journal* authorship was made.

Table 7. Frequency of *AJAE* (*JFE*) publication by the 38 "most-cited" authors, 1959–1968*

	Regular Issues		December Issues		Total	
1.	Heady	(15)	Brandow	(6)	Heady	(18)
2.	Breimyer	(11)	Halter	(5)	Breimyer	(15)
3.	Waugh	(8)	Schultz	(5)	Schultz	(12)
4.	Hathaway	(7)	Breimyer	(4)	Brandow	(11)
5.	Judge	(7)	Cochrane	(4)	Halter	(10)
6.	Schultz	(7)	Fox	(4)	Hathaway	(10)
7.	Dean	(6)	Ruttan	(4)	Ruttan	(10)
8.	Fuller	(6)	Castle	(3)	Cochrane	(9)
9.	Ruttan	(6)	Hathaway	(3)	Waugh	(9)
10.	Brandow	(5)	Heady	(3)	Castle	(8)
11.	Carter	(5)	Bishop	(2)	Judge	(8)
12.	Castle	(5)	Bonnen	(2)	Carter	(7)
13.	Cochrane	(5)	Carter	(2)	Dean	(7)
14.	Griliches	(5)	Clawson	(2)	Fuller	(6)
15.	Halter	(5)	Foote	(2)	Kelso	(6)
			Kelso	(2)		

* Parentheses indicate number of articles authored. Only the 15 (16 in the case of December) authors who had the most published are listed.

Since there was some problem in assuring that all co-authored references were properly tabulated, even for the "Top 38," and since some of the "Top 38" wrote with a co-author, it might be useful to look at and record the numbers of times the "Top 38" were "referenced" on those items the individual himself wrote (Table 8). Schultz and Griliches head this list with works written only by themselves cited 159 and 130 times, respectively. In comparison with the first column of Table 6, the total column in Table 8 shows clearly that while some of these authors write much with others, others are more prone to write alone and this accounts for the difference in order on the two lists.

The 25 references cited most often in the *AJAE* (*JFE*) 1959 to 1968 are listed in Table 9; also given is the number of times each was cited. Some are "classics," some are fairly recent, eight are *Journal* articles, and all 25 are cited more often than any other references in the *Journal* during this time.[10]

The Association's publication prize winners between 1945 and 1968 who were cited as references between 1959 and 1968 are given in Table 10. Examined were references to winners

Table 8. Ranking of the "Top 38" considering only items not co-authored, 1959–1968*

	Regular Issues		December Issues		Total	
1.	Schultz	(114)	Schultz	(45)	Schultz	(159)
2.	Griliches	(111)	Heady	(21)	Griliches	(130)
3.	Nerlove	(69)	G. L. Johnson	(21)	Nerlove	(76)
4.	Cochrane	(51)	Ruttan	(21)	Heady	(72)
5.	Heady	(51)	Ciriacy-Wantrup	(20)	Cochrane	(70)
6.	D. G. Johnson	(42)	Cochrane	(19)	D. G. Johnson	(60)
7.	Stigler	(41)	Griliches	(19)	Stigler	(54)
8.	Brandow	(37)	Nicholls	(19)	Brandow	(52)
9.	Fox	(31)	D. G. Johnson	(18)	G. L. Johnson	(49)
10.	G. L. Johnson	(28)	Bishop	(17)	Fox	(48)
11.	Waugh	(28)	Breimyer	(17)	Ruttan	(45)
12.	Day	(25)	Fox	(17)	Ciriacy-Wantrup	(44)
13.	Breimyer	(24)	Boulding	(16)	Breimyer	(41)
14.	Ciriacy-Wantrup	(24)	Bonnen	(15)	Nicholls	(39)
15.	Ruttan	(24)	Brandow	(15)	Boulding	(38)
16.	Theil	(24)	Clawson	(15)	Waugh	(37)
17.	Boulding	(22)	Bain	(14)	Day	(35)
18.	Hathaway	(22)	Hathaway	(13)	Hathaway	(35)
19.	Kelso	(21)	Stigler	(13)	Bishop	(31)
20.	Solow	(21)	Black	(11)	Theil	(30)

* Parentheses indicate number of times cited. See Table 6.

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[9] Also, as one reviewer has pointed out, some people who are invited to give a paper which subsequently appears in the Proceedings might never (by choice or otherwise) submit a paper for the regular issues.

[10] Where the table lists "various editions" of a book instead of a date of publication, the book had more than one printing to which a reference was made.

of awards for Best Journal Article, Best Published Research, and Honorable Mention.[11]

It surely must be significant that three winners of the prize for Best Article, 19 winners of the prize for Best Published Research, and three recipients of an Honorable Mention award were *never* cited as a reference in *any Journal* article during the period analyzed. Equally impressive is the small number of these prize winners which were referred to several times in later *Journal* articles. Is it fair to say that this is an indictment of the process by which these prize winners are (or were) selected? It appears that these items were not thought worthy of later citation or reuse. Surely they cannot have been so all-encompassing and profound as to eliminate the need for any further writings on the subjects which they covered. Indeed, this is not intended to detract from the professional ability or status of prize winners themselves. Rather it might be taken as a commentary on the process or procedure which awards items and articles (good though they may be) for which *Journal* writers have little or no further use.[12]

Summary

This study has considered some 1,864 articles, 13,272 references, and an undetermined number of authors. Observed were aspects of content and makeup of the *Journal*, references, all authors of the references, a select few of these authors, and the Association's prize winners.

One assessment of published material has been presented; admittedly other approaches may exist and be valid. A professional journal, while primarily a medium to present research, serves other purposes and masters and service thereto may not necessarily be reflected in a study such as this one. Hopefully other approaches for viewing and estimating relevance and usefulness will be presented in the future. It is, of course, a tautology that the prime utility of a professional journal lies mainly in its use by that profession.

Do the articles have pragmatic appeal? Do

Table 9. 25 references cited most often in the *AJAE* (*JFE*) 1959–1968*

1. George E. Brandow, "Interrelations Among Demands for Farm Food Products and Implications for Control of Market Supply," Pennsylvania Agricultural Experiment Station Bulletin 680, 1961. (27)
2. Alfred Marshall, *Principles of Economics*, Various Editions. (23)
3. Theodore W. Schultz, *The Economic Organization of Agriculture*, 1953. (23)
4. Theodore W. Schultz, *Transforming Traditional Agriculture*, 1964. (22)
5. Zvi Griliches, "Research Expenditures, Education, and the Aggregate Agricultural Production Function," *American Economic Review* 54:6, 1964, pp. 961–974. (21)
6. Marc Nerlove, *The Dynamics of Supply: Estimation of Farmers' Response to Price*, 1958. (20)
7. Joe S. Bain, *Industrial Organization*, Various Editions. (19)
8. Earl O. Heady, *Economics of Agricultural Production and Resource Use*, 1952. (19)
9. Wilfred Candler and Earl O. Heady, *Linear Programming Methods*, 1958. (18)
10. Marc Nerlove, "Distributed Lags and Demand Analysis for Agricultural and Other Commodities," USDA Agricultural Handbook Number 141, 1958. (18)
11. Willard W. Cochrane, *Farm Prices: Myth and Reality*, 1958. (17)
12. George J. Stigler, *The Theory of Price*, Various Editions. (16)
13. Zvi Griliches, "The Demand for Fertilizer: An Economic Interpretation of a Technical Change," *Journal of Farm Economics* 40:3, 1958, pp. 591–606. (14)
14. Vernon W. Ruttan and Thomas T. Stout, "Regional Patterns of Technological Change in American Agriculture," *Journal of Farm Economics* 40:2, 1958, pp. 196–207. (14)
15. William Addison and Marc Nerlove, "Statistical Estimation of Long-Run Elasticities of Supply and Demand," *Journal of Farm Economics* 50:4, 1958, pp. 861–880. (13)
16. Robert Dorfman, Paul A. Samuelson, and Robert M. Solow, *Linear Programming and Economic Analysis*, 1958. (13)
17. Maurice M. Kelso, "A Critical Appraisal of Agricultural Economics in the Mid-Sixties," *Journal of Farm Economics* 47:1, 1965, pp. 1–16. (13)
18. ——, *Food From Farmer to Consumer*, Report of the National Commission on Food Marketing, 1966. (12)
19. Kenneth E. Boulding, *Economic Analysis*, Various Editions. (11)
20. Richard J. Foote, "Analytical Tools for Studying Demand and Price Structures," USDA Agricultural Handbook Number 146, 1958. (11)
21. Zvi Griliches, "The Demand for Inputs in Agriculture and a Derived Supply Elasticity," *Journal of Farm Economics* 41:2, 1959, pp. 309–322. (11)
22. Marc Nerlove, "Distributed Lags and Estimation of Long-Run Supply and Demand Elasticities: Theoretical Considerations," *Journal of Farm Economics* 40:2, 1958, pp. 301–311. (11)
23. Robert M. Solow, "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics* 39:3, 1957, pp. 312–320. (11)
24. Zvi Griliches, "Specification Bias in Estimates of Production Functions," *Journal of Farm Economics* 39:1, 1957, pp. 8–20. (10)
25. Marc Nerlove, "Estimates of the Elasticities of Supply of Selected Agricultural Commodities," *Journal of Farm Economics* 38:2, 1956, pp. 496–509. (10)

* Number of times used noted in parentheses.

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[11] As in Tables 2 and 3, the figures on any one line are not cumulative. Each of the three columns for each prize category is totally autonomous. In each column the total number of prize winners in that category is observed. Only the distribution changes.

[12] In relation to the selection process as well as the relevance of awards, the customs and concepts including the efficacy of the whole procedure have been recently questioned and to a lesser degree, examined [1, 2, 3, 4].

Table 10. Number of *AAEA* (*AFEA*) prize winners cited as references, 1959–1968

Number of Times Cited	Number of Best Articles Cited			Number of Best Published Research Items Cited			Number of Honorable Mention Items Cited		
	Regular Issues Only	December Issues Only	All Issues*	Regular Issues Only	December Issues Only	All Issues*	Regular Issues Only	December Issues Only	All Issues*
0	6	17	3	22	36	19	5	7	3
1	6	1	6	11	11	7	3	4	4
2	5	0	5	5	4	7	2	2	2
3	3	2	4	7	4	5	0	0	0
4	0	2	0	4	1	9	1	0	2
5	0	0	1	3	1	2	0	0	0
6	1	0	1	0	0	2	1	0	0
7	0	0	1	2	0	3	0	0	0
8	0	0	0	0	0	0	0	0	1
10	1	0	1	0	0	0	0	0	0
14	0	0	0	0	0	0	1	0	0
15	0	0	0	2	0	0	0	0	1
16	0	0	0	1	0	0	0	0	0
18	0	0	0	0	0	1	0	0	0
19	0	0	0	0	0	1	0	0	0
21	0	0	0	0	0	1	0	0	0
Total			22			57			13

* The figures in the Regular Issues and December Issues columns for a given "Number of Times Cited" do *not* accumulate directly across to the "All Issues" column. For instance, a prize winner cited once in Regular Issues and once in December Issues would be cited twice in "All Issues."

the awards reflect relevance? Is the *Journal* reaching our profession *en masse*? The intent of this article has been to ask as well as, in some degree, to answer these queries.

References

[1] Castle, Emery N., "Has the AAEA Become 'Awards Happy'?: A Reply," *Am. J. Agr. Econ.*, 54:140–141, Feb. 1972.

[2] ———, "Report of the Awards Committee," *Am. J. Econ.*, 52:858–860, Dec. 1970.

[3] Cramer, Gail L., "Ph.D. Dissertation Awards: Does the Best Always Win?—Comment," *Am. J. Agr. Econ.*, 54:141, Feb. 1972.

[4] Grove, Ernest W., "Has the AAEA Become 'Awards Happy'?: A Comment," *Am. J. Agr. Econ.*, 54:139–140, Feb. 1972.

[5] Littleton, Isaac Thomas, *The Literature of Agricultural Economics: Its Bibliographic Organization and Use*, North Carolina Agr. Exp. Sta. Tech. Bull. 191, March 1969.

Economic Aspects of Ground Water Resources and Replacement Flows in Semiarid Agricultural Areas

MICHA GISSER AND ABRAHAM MERCADO

This article integrates an agricultural demand function for water with a hydrologic model of an aquifer in a semiarid region. The model can aid policy-makers with problems from overdraft leading to a falling water table and with examination of the profitability of importing water from surplus areas and artificially recharging the aquifer.

An attempt is made here to integrate the economic theory of the agricultural sector with a hydrologic theory of ground water and replacement flows in one model. The agricultural sector is represented in the model by a demand function for irrigation water in a certain basin. Ground water is represented by a one cell model of an aquifer and replacement flow which are charged artificially into the ground. The link between the models is as follows: the cost of water determines, via the demand function, the amount of water used. But in turn, the amount of water used per unit of time determines the water level, and the water level determines the cost of ground water. The aquifer benefits from a significant natural recharge. Although the annual natural recharge is a stochastic variable, its expectation is known. The aquifer loses water via a process of natural discharge which is functionally related to the water level, and the parameters of this function are known. In this paper, concern is with the long-run steady-state solutions characterized by an eventual equilibrium in which, if necessary with the help of artificial recharge, overdraft is reduced to zero. Accordingly, one purpose of this paper is to provide a theoretical integration of *economic* and *hydrologic* analysis of replacement flows. The economic problem essentially is to select the *replacement flow project* that will leave the farm community with the maximum profit (net income) and an aquifer that is in a steady state. From the hydrologic viewpoint, a variety of replacement flow projects yield steady-state solutions. But given the cost of pumping and the cost of replacement flows, only one project simultaneously yields maximum profit for the farm community and a steady-state solution.

Results of this study are different from the results reached by Kelso [10] in two respects. First, overdraft must not lead to agricultural abandonment. An overdraft may lead to an equilibrium in which overdraft will be reduced to zero. If this is not the case, importing water from out-of-basin sources should be considered. Second, a hydrologic model of a single cell is integrated with the demand function for irrigation water. This is an improvement of Kelso's model.

Background

Economic aspects of ground water have been studied by several economists. Kelso [10], discussing the problem of the water stock in central Arizona, assumed that: (a) water yielding efficiency of the falling aquifer remains constant with depth; (b) pumping cost per acre foot per foot of lift is constant regardless of depth; and (c) the only variable affecting net revenue within any farming system is pumping cost. This article might be viewed as an extension of Kelso's 1961 paper with assumption (c) being replaced by the more realistic assumption that there is a negatively sloped demand curve for irrigation water. Also, Kelso's assumptions about the aquifer are replaced here by a pure hydrologic model of a single cell. Milliman [11] and Renshaw [12] studied ground water allocation problems. Renshaw in particular showed that storing water in ground reservoirs may lower the cost of pumping. Burt [4] developed other interesting aspects of reservoir management. He utilized a mathematical programming approach [3, 5, 6, 7] to develop a demand function for irrigation water that was further utilized in a dynamic programming formulation of the aquifer management problem. Burt's solution was characterized by an eventual equilibrium with overdraft reduced to zero.

In a complex model Rogers and Smith [13] studied the problem of ground and surface water in irrigation project planning. Bredehoeft and Young [2] formulated the problem for more complex aquifer conditions in which water

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drawdown and hence the pumping lift at a particular location is usually not directly related to the basin-wide average. In contrast, the approach presented here considers a simplified single-cell aquifer model. The model is based on the realistic assumption that basin-wide variations in hydrologic conditions do not deviate in any significant way from the basin-average; i.e., farmers' behavior is mainly determined by the overall level of the water table rather than by variations in that table. Bear and Levin [1] studied optimal utilization of an aquifer as an element of a water resources system; they provided a theoretical framework in which a demand curve for water is an integral part of an aquifer model. The present paper can be considered as an adaptation of parts of Bear and Levin's study to a specific agricultural-economic problem where the demand curve of irrigation water can be estimated empirically. Thus, this study is an extension of Kelso's as well as Bear and Levin's studies. Empirical aspects of replacement flows in the Pecos Basin have been studied [8, 9].

But a theoretical summary of the issue of replacement flows is necessary. Economic problems of aquifers supplying water for agricultural irrigation *in conjunction with replacement flows* and the hydrology of an aquifer have not been adequately treated at the theoretical level. This is the main goal here. After discussion of the model, the authors consider some institutional problems that arise in formulating optimal ground water and replacement flow economic policies. It seems that such institutional problems deserve the attention of the economist in order to avoid simplifying the problem beyond the point of relevance for policy makers.

The Hydrologic Model

A single cell model of a basin is described with the following notations:

Symbol	*Description*
H	water table
R	natural recharge
R_a	artificial recharge
W	water pumped
W_n	natural discharge
α	coefficient of return flow
AS	storativity of the aquifer (A = the area, and S = the storage coefficient).

The coefficient of return flow (α) appears in such a way that return flows are assumed to reach the water table practically instantaneously. However, under many aquifer conditions and where the water table is relatively deep, return flows may require years or even decades to reach the water table. Definitely under such conditions the model would become invalid, and a more complicated model would be needed.

In Figure 1 the single cell model of the aquifer is geometrically described. Over a period of time the single cell gains the natural recharge, artificial recharge, and return flow: $R+R_a+\alpha W$. It loses the water pumped and natural discharge: $W+W_n$.

Natural discharge is a linear function of H, hence it can be written as

$$W_n = a + bH. \tag{1}$$

In what follows, $R_a=0$ unless otherwise stated. The differential equation which describes the water table as a function of time is

$$AS\frac{dH}{dt}=R+R_a+(\alpha-1)W-(a+bH). \tag{2}$$

The steady state solution is obtained by setting (2) equal to zero,

$$R+R_a+(\alpha-1)W-(a+bH_s)=0 \tag{3}$$

where H_s is the water level under steady-state conditions. If it could be assumed that farmers are insensitive to changes in the price of water, then W is constant and the solution of (2) would show how the water table behaves over time.

Solving (2) for fixed W gives

$$H=[R+R_a+(\alpha-1)W-a]/b+\{[bH_o-R-R_a-(\alpha-1)W+a]/b\}\exp\left\{\frac{-b}{AS}t\right\}. \tag{4}$$

If artificial recharge is absent ($R_a=0$) and the right-hand side of equation (2) is originally negative, the water table will continue to fall

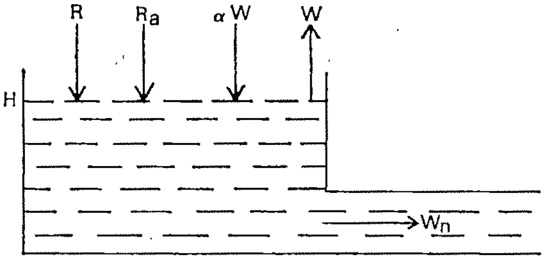
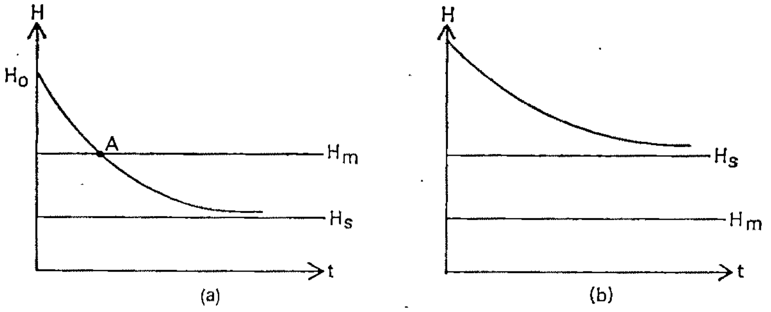


Figure 1



(a) (b)

Figure 2

until it reaches either the minimum allowable level (to be defined shortly) or the steady state level. Steady-state conditions are achieved only if the possibility of the inequality $W_n < 0$ is ignored. From (3) the steady state level is derived as follows:

$$(5) \quad H_s = [R + R_a + (\alpha - 1)W - a]/b.$$

This definition can also be derived from equation (4) by letting t approach infinity. The minimum allowable level (denoted by H_m) is defined as a level of H such that if H falls below it, the aquifer will suffer unacceptable damages for a long time period. For example, if the water table falls below level H_m, the aquifer will be infiltrated by neighboring salty aquifers and the salinity of its ground water will rise to an unacceptable level. Another possibility is that H_m is simply the bottom of a confined aquifer. In this case, due to the stochastic nature of natural recharge, pumping becomes a problem. Another case is that if the water table is below a certain level, the flow from the aquifer to a river will be reversed in direction; such a reversal may be legally unwanted. For reference see [14, Ch. 12]. Panel (a) in Figure 2 describes the case where $H_s < H_m$. Panel (b) in Figure 2 describes the case where $H_s > H_m$.

Integrating the Hydrologic Model With the Demand Curve for Irrigation Water

To keep the mathematics simple, the assumption is made that agricultural demand for water is linear. Let this demand curve be

$$(6) \qquad W = g + kP$$

where P is the price of water. If depth is denoted by D, and S_L is a certain level used for reference, then the cost of pumping water is $P = c_o' + c_1'D = c_o' + c_1'(S_L - H)$, where c_o' represents the cost of fixed capital plus the fact that the dynamic drawdown can roughly be considered as giving rise to a fixed cost. The coefficient c_1' is the marginal pumping cost per acre-foot per foot of lift. If $c_o = c_o' + c_1'S_L$ and $c_1 = -c_1'$, a simple linear function which relates the cost of pumping to the water table is obtained as follows:

$$(7) \qquad P = c_o + c_1 H.$$

Substituting (7) in (6),

$$(8) \qquad W = d + k \cdot c_1 H$$

where d is equal to $g + k \cdot c_o$.

Substituting (8) in (2), the following differential equation is obtained:

$$(9) \quad AS\frac{dH}{dt} = R + R_a + (\alpha - 1)(d + k \cdot c_1 H) - (a + bH).$$

This differential equation is derived from an integrated model in which economic, as well as hydrologic, aspects are present. The steady state condition for (9) is equation (3) where W is replaced by (8). The solution for (9) is given by

$$(10) \quad H = \frac{a - (\alpha - 1)(g + kc_o) - R - R_a}{(\alpha - 1)kc_1 - b} + \left\{\frac{R + R_a + (\alpha - 1)(g + kc_o)}{(\alpha - 1)kc_1 - b} + \frac{-a + [(\alpha - 1)kc_1 - b]H_o}{(\alpha - 1)kc_1 - b}\right\} \cdot \exp\left\{\frac{[(\alpha - 1)kc_1 - b]t}{AS}\right\}.$$

The steady-state solution is

$$(11) \quad H_s = \frac{a - (\alpha - 1)(g + kc_o) - R - R_a}{(\alpha - 1)kc_1 - b}.$$

Figure 2 describes the two alternative possibilities. Clearly, if the water table reaches first its steady state level and if $R_a=0$, (Fig. 2, panel [b]), there is no need to consider replacement flows. However, if the minimum allowable level is reached before the steady state level is reached (Fig. 2, panel [a], point A) replacement flows should be considered. If replacement flows are not available, farmers must be restricted to pumping a limited amount denoted by W_r, satisfying equation (3) as follows:

$$(12) \quad R + (\alpha - 1)W_r - (a + bH_m) = 0$$

where $R_a=0$.

Replacement Flows

Consider a situation in which point A in panel (a) of Figure 2 is reached. At that point, $R_a=0$, and

$$(13) \quad R + (\alpha - 1)W_m - (a + bH_m) < 0.$$

If an amount R_a^* indicated by (14) could be artificially recharged, a steady state solution at the minimum allowable water table could be achieved:

$$(14) \quad R_a^* = 0 - [R + (\alpha - 1)W_m - (a + bH_m)].$$

Clearly this solution would be possible only if artificial recharging is costless. If artificial recharging is costly, and if for the sake of efficient allocation of resources farmers are charged a fee that generally covers the cost of artificial recharging, then a new solution must be sought.

Three different prices should be considered:

P_1 = cost per unit of water pumped.

P_2 = cost per unit of replacement water artificially recharged. This includes the cost of shipping the water as well as recharging. In this model it is assumed that this cost is a linear function of the amount of water artificially recharged (R_a).

P_3 = price charged to farmers under the assumption that it must cover the cost of artificially recharging replacement flows.

To obtain the steady state solution, five equations in six unknowns (P_1, P_2, P_3, H_s, R_a, and W) must be solved:

$$(7.1) \quad P_1 = c_o + c_1 H_s$$

$$(15) \quad P_2 = z_o + z_1 R_a$$

$$(16) \quad P_3 = \frac{P_1 W + P_2 R_a}{W}$$

$$(6.1) \quad W = g + kP_3$$

$$(3.1) \quad R + R_a + (\alpha - 1)W - (a + bH_s) = 0.$$

Thus for any given level of H_s the above five equations can be solved. Suppose the solution yields a certain level of R_a, denoted by R_a^*. Given this, the following differential equation is obtained:

$$(17) \quad AS\frac{dH}{dt} = R + R_a^* + (\alpha - 1) \cdot \tfrac{1}{2}\left\{g + k(c_o + c_1 H) + \sqrt{[g + k(c_o + c_1 H)]^2 + 4k(z_o + z_1 R_a^*)R_a^*}\right\} - (a + bH).$$

Let the right-hand side of (17) equal Y. Equation (17) can then be solved numerically by application of the following difference approximation:

$$(18) \quad H(t + \Delta t) = H(t) + Y\frac{\Delta t}{AS}.$$

Initial value of H denoted by H_o corresponds to the time when the artificial recharging of R_a^* begins. Equation (18), when numerically solved, provides the path of the water level from H_o to the new H_s.

There is not necessarily a solution for the above system. If P_3 is high such that $W=0$, there is no steady state solution which satisfies the above equations.

The remaining stage is to determine the best solution. Given that H_s is a parameter that varies in a certain allowable range, it can be varied and the corresponding set of W, R_a, and P_3 (P_2 and P_1) found. This set plus the production function, prices of other inputs, and prices of outputs are sufficient to determine total agricultural profit. It is likely that the highest level of profit will be the level selected for determining the optimal level of R_a, for example, but other considerations may also influence the policy decision.

More specifically, consider the following aggregate agricultural production function,

$$(19) \quad Q = f(W, A, B_o),$$

where Q is agricultural output, W is water, A is a variable input, and B is an input fixed at a level of B_o. Farmers are confronted with parameters P_q, P_3, and P_a, the prices of output, water, and the variable input, respectively. If profit is denoted by Π, then

$$(20)\quad \Pi = Q\cdot P_q - W\cdot P_3 - A\cdot P_a - B_o\cdot P_b.$$

Maximization of profit plus the production function give rise to the following three equations in three unknowns:

$$(21)\quad \frac{\partial Q}{\partial W} P_q = P_3$$

$$(22)\quad \frac{\partial Q}{\partial A} P_q = P_a$$

$$(19)\quad Q = f(W, A, B_o).$$

The three unknowns are W, A, and Q. Accordingly, when the price of water (P_3) varies, in addition to water, the amount of input A as well as output are obtained.

Thus, for each level of H_s a price of water, P_3, is obtained. For each price P_3 the maximum profit is obtained. Let the maximum profit for each level of H_s be denoted by Π^*. Then a new function is defined as follows:

$$(23)\quad \Pi^* = \phi(H_s),\ H_m < H_s < H_u$$

where H_u is the upper limit of the water table. Differentiating Π^* with respect to H_s and equating to zero (in principle) gives the maximum of Π^*. This maximum is denoted by Π^{**}, and the corresponding level of H_s will be the steady-state level of the water table.

Institutional Problems

Some institutional problems arise. First, who will invest in a project of bringing water from far away and recharging it to the aquifer? If the source of imported water as well as the basin under consideration are within the borders of a single state, such a project may be the responsibility of the state. However, if the source of water is outside the state and the basin is inside a single state or it extends over the borders of many states, an interstate or federal project is called for.

Second, notice that the price P_3 has two components,

$$(24)\quad P_3 = \frac{P_1W + P_2R_a}{W} = P_1 + \frac{P_2R_a}{W}.$$

In (24) P_1 is the average cost of pumping. However, the second expression, $(P_2R_a)/W$, is a fee that is the total annual (flow) cost of the project of importing water divided by the amount of water pumped. Thus, a governmental agency would have to gauge use of water by each farmer and impose a levy of $(P_2R_a)/W$ per acre-foot. This is feasible, mainly because water-meters are already required in such cases. Also, state and federal agencies to carry out such projects already exist.

Summary and Conclusion

In semiarid areas in which farmers confront falling water tables, hydrology and economics must be combined in an integrated model to provide rational solutions to pressing problems. Such a model presented here combines a single cell hydrologic model with a *(linear) negatively sloped demand* function for irrigation water. This model enables both the economist and the hydrologist to consider alternative policies to cope with the problem of falling water tables. First, no policy may be needed if use of the model allows prediction that a steady-state level will be reached before the allowable minimum level. Second, if the minimum allowable level is reached prior to the steady-state level, the model lends itself easily to a comparison of two alternative policies, (a) restricting the water pumped to a level that will yield a steady-state condition of the minimum allowable level of the water table, and (b) artificially recharging replacement flow and investigating the steady-state solutions corresponding to it.

References

[1] BEAR, J., AND O. LEVIN, "Optimal Utilization of an Aquifer as an Element of Water-Resources System," in *Selected Works in Operations Research and Hydraulics, Published in Memory of Oded Levin*, Haifa, Israel, Technion, June 1970.

[2] BREDEHOEFT, JOHN D., AND ROBERT A. YOUNG, "The Temporal Allocation of Ground-Water—A Simulation Approach," *Water Resour. Res.* 6:3–21, Feb. 1970.

[3] BURT, O. R., "Optimal Resource Use over Time with an Application to Ground Water," *Mgt. Sci.* 11:80–93, 1964.

[4] ———, "The Economics of Conjunctive Use of Ground and Surface Water," *Hilgardia* 36:31–111, Dec. 1964.

[5] ———, "Economic Control of Ground Water Reserves," *J. Farm Econ.* 48:632–647, Dec. 1966.

[6] ———, "Temporal Allocation of Ground Water," *Water Resour. Res.* 3:45–56, First Quarter 1967.

[7] ———, "Groundwater management under Quadratic Criterion Functions," *Water Resour. Res.* 3:673–682, Third Quarter 1967.

[8] GISSER, M., "Linear Programming Models for Esti-

mating the Agricultural Demand Function for Imported Water in the Pecos River Basin," *Water Resour. Res.* 6:1017–1024, Aug. 1970.

[9] ———, AND A. MERCADO, "Integration of the Agricultural Demand Function for Water and the Hydrologic Model for the Pecos Basin," *Water Resour. Res.* 8:1373–1384, Dec. 1972.

[10] KELSO, M. M., "The Stock Resource Value of Water," *J. Farm Econ.* 43:1112–1129, Dec. 1961.

[11] MILLIMAN, J. W., "Commonality, the Price System and the Use of Water Supplies," *Southern Econ. J.* 22:426–437, April 1956.

[12] RENSHAW, E. F., "The Management of Ground Water Reservoirs," *J. Farm Econ.* 45:285–295, May 1963.

[13] ROGERS, PETER, AND DOUGLAS V. SMITH, "The Integrated Use of Ground and Surface Water in Irrigation Project Planning," *Am. J. Agr. Econ.* 52:30–35, Feb. 1970.

[14] TODD, DAVID K., *Ground Water Hydrology*, New York, John Wiley and Sons, 1963.

Application of Dynamic Programming in Markov Chains to the Evaluation of Water Quality in Irrigation*

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With the aid of a dynamic programming model in Markov chains, this paper presents an economic analysis of irrigation with saline water. Results provide guides to optimal irrigation policy. Estimates of the value of water quality in irrigation are derived, and possible applications in water resource development decisions are discussed.

CONSIDERABLE experimental work has been carried out regarding the effect of water quality on crop yields [1, 2, 3, 6, and 11], but relatively few studies on the economic dimension of the subject have been published [9, 10, 12, 13, and 14]. Most of the economic-oriented studies adopt a static framework and neglect the dynamics of the system. Such dynamics play an important role in situations typical to the Mediterranean climate, where a dry summer irrigation season is followed by a rainy winter with stochastic quantities of rainfall. This paper emphasizes the dynamic aspects of irrigation with saline water over a sequence of years.

In an analysis of the value of water quality in irrigation, a distinction should be made between three ranges of time and three corresponding models:

(a) A "short run" model refers to relationships confined to a single irrigation season. The model refers to the initial salinity of the soil profile at the beginning of the irrigation season as given, for each initial state analyzes the optimal combination between water quantity and quality but does not take into account the effects of accumulation of salt over time. "Short run" irrigation problems are not discussed in detail here (refer to [5 and 14]).

(b) A "long run" model accounts for the effects of salt accumulation in the soil profile over time. It comprises a succession of short run processes, the initial conditions of which are affected by salt accumulation in previous periods; irrigation decisions over a single season take into account the resulting terminal conditions due to each alternative and the effects in succeeding periods.

(c) An "extended long run model" takes into account both salt accumulation in the soil profile and its accumulation in the underground water reservoirs.

This paper is restricted to the "long run" only. It neither explores irrigation decisions in the "short run" nor discusses the "extended long run" effects of salinity accumulation in underground reservoirs.

The Long Run Model

The basic conception is one of an N stage dynamic system, with a given number (M) of states, a succession of decision options, random events, transformation functions of the system from one state to another, and a profit (or loss) function related to the decision options and the states of the system. The nature of the problem fits well the dynamic programming model in Markov chains [8].

Two major situations concerning crop types can be distinguished. (a) In irrigation of perennial crops, such as citrus, the problem is to determine the optimal combination of water quantity and quality with the crop being constant. Farmers have the option to replace the crop if it is unprofitable over a series of years. (b) In irrigation of annual crops, such as field crops and vegetables, the problem is to determine both the optimal rotation of crops and corresponding irrigation policies. In this paper analysis is confined to a perennial crop (citrus).

The model can generally be applied to analysis of alternative irrigation decisions in regard to quantity and quality of irrigation water at any time of the year. Due to limitations of empirical information, the specific model presented below relates to a subset of the overall decision options and is confined to the analysis of winter leaching policy. Quantity and quality of summer irrigation water is assumed to be

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constant. Water quality is varied parametrically, exogenously to the model.

A planning horizon of N stages or years is referred to with a single year being a basic unit in the sequence. Each year begins at the end of the winter rainy season. It is assumed that all rainfall is confined to the winter season, this being a good approximation to reality for the Mediterranean climate. The empirical analysis relates to a subhumid region in which need for supplementary irrigation during the winter season is negligible.

The following elements comprise the model:

$\xi_i(n)$ denotes state i at the beginning of year n, at the termination of the rainy season of the previous year. It is defined in terms of mean chloride concentration in the soil profile to a depth of 90 cm (m.e. Cl/l on a saturated paste basis). Fifty discrete states are distinguished, $(i=1, 2, \cdots, 50)$.

d_i^k is the kth decision $(k=1, 2, \cdots, K)$ taken at state i in any year. Definition of the feasible decision set, from which the kth decision is selected, is independent of the state of the system and the year in the sequence; it is assumed that in all states and years the same decisions are *a priori* acceptable. The d_i^k decisions are defined in terms of quantity of water used to leach the soil profile at the end of winter and before the summer irrigation season. The rationale for the definition of such decision options follows from a study by Bresler and Yaron [5] that implies that the best timing for leaching is when the profile is saturated. Another reason for testing the validity of leaching at the end of the winter season is the relative abundance of water supply as compared with demand for water at this time, a fact reflected in the alternative cost of water.

Quality (salinity) of water is referred to as a parameter exogenous to the model with a different salinity level for each run. The quantity of water applied during the irrigation season is assumed to be constant at the level practiced by farmers. The model can be adapted easily to accommodate the quality of water as an endogenous variable and varying summer irrigation levels as additional decision options.

$\theta_r(n)$ is the random rth level of rainfall in year $n(r=1, 2, \cdots, R)$, with probability $p[\theta_r(n)]$. $(\sum_{r=1}^{R} p[\theta_r(n)]=1.)$ It is assumed that the probability distribution of rainfall in year n is independent of the rainfall in year n. p_{ij}^k is the transformation probability of the system from state i to state j following the kth decision with the corresponding transformation function being

$$(1) \qquad \xi_j(n-1) = t^k[\xi_i(n), \theta_r(n)].$$

For a given combination of state $\xi_i(n)$, decision d_i^k, and a rainfall level $\theta_r(n)$, there is a unique transformation from $\xi_i(n)$ to $\xi_j(n-1)$ with a probability p_{ij}^k.

Due to the complexity of the transformation (1) and the sequential nature of the salt leaching and accumulation process, this function was expressed in the empirical study by three successive auxiliary functions: (a) a salt leaching function expressing the effect of the leaching irrigation at the end of the rainy season,

$$(1.1) \qquad \xi_s^*(n) = g[\xi_i(n), d_i^k]$$

where ξ_s^* is the adjusted chloride concentration in the soil profile due to the leaching decision d_i^k; (b) a summer irrigation accumulation and/or leaching function,

$$(1.2) \qquad \xi_p^{**}(n) = g'[\xi_s^*(n)]$$

where ξ_p^{**} is the fall soil chloride concentration due to summer irrigation of a constant quantity; and (c) a winter rainfall leaching function,

$$(1.3) \qquad \xi_j(n-1) = g''[\xi_p^{**}(n), \theta_r(n)].$$

It is easily seen that integration of the functions (1.1) through (1.3) by successive substitutions gives the unique expression of the function (1).

f_i^k is the immediate net return in any year n derived from decision k at state i. It comprises (a) negative or zero returns, due to cost of leaching at the end of the winter and (b) a positive return due to the yield achieved in response to decision k at state i. This return takes into account the loss accrued to the yield due to salt concentration in the soil profile in the course of a single year.

$\Lambda_i(n)$ is the maximal expected value of cumulative net return at state i in year n computed as in (2) below. The problem is to maximise $\Lambda_i(N)$ for any initial state i, using the recursive equation

$$(2) \qquad \Lambda_i(n) = \max_k \left[f_i^k + \alpha \sum_{j=1}^{M} p_{ij}^k \Delta_j(n-1) \right]$$

where $\alpha<1$ is a time discount factor, and $\Lambda_i(O)=0$ for all i, for N large enough.

Empirical Application of the Model

In this section an application of the model to an economic evaluation of water quality for a selected case is presented. The case relates to citrus production—Shamouti on sweet lime root stock—on medium texture soil ($SP=37.5$) in the Northern Coastal Plain of Israel, with mean annual rainfall of approximately 600 mm.

Economic data (yield, price, fixed and variable cost) were obtained from a citrus profitability survey in Israel [7]. Since these data are of local relevance, they are not presented here; however, note that the yield referred to was 12.4 tons per acre.[1]

The physical relationships used are described as follows:

(a) End winter salt leaching (1.1) was evaluated according to a model proposed by Bresler [4]. The soil profile was divided into three layers of 30 cm each, through which the body of water perforates. It was assumed that the soil profile was saturated to field capacity at the time of leaching, apparently a reasonable approximation for this time of year, and that leaching could be carried out in the course of a single irrgiation only.

(b) Evaluation of salt accumulation and/or leaching during the summer irrigation season (1.2) was based on the law of mass conservation, whereby the amount of salt added to the soil profile by the body of water less the amount leaching out is equal to the terminal salinity content of the profile. The above basic identity can be written as

$$Q_w Cl_w - \beta Q_w \frac{(\xi^* + \xi^{**})}{2} = (\xi^{**} - \xi^*)V \tag{3}$$

where

Q_w = depth of irrigation applied (mm);
Cl_w = chloride concentration in the irrigation water (m.e. Cl/l);
β = fraction of irrigation water applied being leached out of the profile; and
V = amount of water contained in the relevant soil profile (mm), with ξ^* and ξ^{**} as defined above.

The parameter β was evaluated to be 0.10. It was necessary to evaluate β due to the lack of detailed empirical information on evapotranspiration and leaching in citrus irrigation.

From equation (3) is obtained relationship (4):

$$\xi^{**} = Q_w Cl_w + \xi^*\left(V - \frac{\beta Q_w}{2}\right) \Big/ \left(V + \frac{\beta Q_w}{2}\right). \tag{4}$$

(c) Leaching of the profile due to rainfall (1.3) was also computed on the basis of the above-mentioned relationship pertaining to the law of mass conservation. In this case, the salinity of rain was taken as being zero. Therefore identity (3) can be modified to

$$\gamma R \frac{[\xi^{**}(n) + \xi(n-1)]}{2} = [\xi^{**}(n) - \xi(n-1)]V \tag{5}$$

where R is the amount of rainfall (mm) and $\gamma(0<\gamma<1)$ is the fraction of the amount of rainfall effective in leaching. Other symbols are as defined above. γ was evaluated, on the basis of empirical observations, to equal 0.6. Use of equation (5) results in

$$\xi(n-1) = \xi^{**}(n)\left(V - \gamma\frac{R}{2}\right) \Big/ \left(V + \gamma\frac{R}{2}\right). \tag{6}$$

Frequency distribution of discrete amounts of rainfall for the area of the empirical analysis was obtained from rainfall data accumulated over the last 35 years.

(d) Evaluations of yield loss due to salinity were provided by co-operating soil scientists on the basis of data from local and other sources (see footnote*). It was assumed that average seasonal soil salinity of 7.5 m.e. Cl/l (at saturated extract) caused a yield loss of 10 percent, and soil salinity levels of 10, 15, 20, and 50 m.e. Cl/l caused a yield loss of 20 percent, 35 percent, and 50 percent, respectively.

The model was applied to a sequence of 50 years ($N=50$), long enough to set $\Lambda_i(O)=0$ for all i, (the value of state i at the terminal year of the system), for $\alpha<1$. Rate of interest of 12 percent per year was assumed with $\alpha=1/1.12$. Different levels of irrigation water quality were applied for each run (2, 4, 6, 8, 10, 12, and 14 m.e.Cl/l).

Four leaching policies were tested—0 (no

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[1] Detailed data can be obtained from the authors upon request.

Table 1. Annual expected steady state monetary losses due to soil and water salinity

Initial soil profile salinity m.e. Cl/l	Water salinity m.e. Cl/l 2	4	6	8	10	12	14
				IL/du per year[a]			
5	18	46	97	144	180	206	226
10	22	53	107	153	188	212	232
15	27	59	112	157	191	215	235
20	33	64	116	161	194	218	237
25	38	69	120	163	196	220	239

[a] 4.20 IL (Israeli Lirot) = one U. S. \$; 4 du (dunam) = one acre; IL/du = .954 \$/acre.

leaching), 100, 150, and 200 mm. Quality of water used for leaching was assumed to be the same as that of the summer irrigation water levels for 2–6 m.e. Cl/l and 6 m.e. Cl/l when summer irrigation water of higher salinity was applied. Results of the analysis follow.

It was assumed that the alternative cost of water used for leaching was lower than the "average" alternative cost, due to the particular season for leaching (0.1 IL./m^3 water, equivalent to 2.4 U.S. cents).

Winter leaching

The results provide detailed information on the optimal leaching policy in terms of quantity to be used for each state of the soil profile at the end of the winter, quality of leaching water, and quality of irrigation water in the following summer. It was found that convergence to a steady state policy occurs within three to five years. Optimal steady state policies were derived. For example, using summer irrigation water of quality 6 m.e. Cl/l and leaching water of the same quality, the optimal policy is to apply 200 mm for leaching whenever soil profile salinity is above 8 m.e. Cl/l.

Steady state annual monetary losses

Expected steady state monetary losses on a yearly basis accrued to yields under optimal leaching policy, computed from the results, are presented in Table 1.

Value of water quality

The results presented in Table 1 served as a basis for the estimation of the value of water quality. For example, for an initial soil salinity of 5 m.e. Cl/l the value of one m.e. Cl/l in the water applied to one dunam of Shamouti on sweet lime (700 m^3) in the range 6–8 m.e. Cl/l is

$$\frac{144 - 97}{2} = 23.5, \quad \text{or} \quad \frac{1}{700}$$

of this amount per one m^3, namely, IL. 0.03 approximately.

Corresponding values for the whole range of water quality are as follows:

Range of water quality	2–4	4–6	6–8	8–10	10–12	12–14
Value of one m.e. Cl/l	0.02	0.04	0.03	0.03	0.02	0.01

The values for other initial salinity conditions are of similar magnitude.

Estimated value of initial soil profile salinity

As can be seen from Table 1, the effect of initial soil salinity on yield reduction is in the range of IL. 0.005–0.01 per m.e. Cl/l.

Summary and Discussion

In this paper a long-run approach to the economic evaluation of water quality in irrigation was described. While the emphasis of the paper was on methodology, empirical estimates for one selected situation were presented. The estimates derived relied heavily on assumptions made with regard to salt leaching and accumulation and yield functions. These functions were formulated with the aid of soil scientists on the basis of a considerable amount of field data and may be considered as good approximations to reality.

Decision variables in the analysis were restricted to quantities of water used for leaching, with the quality of water being an exogenous parameter. The model can accommodate other decision variables such as quality of the leaching water, quantity of irrigation water, and intervals between successive irrigations. With minor modifications the model can be applied to analyses of situations in which, beyond the possibility to vary water quantity and quality in irrigation, adjustments can be made in the cropping systems of the farms.

The economic significance of the model and the results which may be derived through its use are on two levels, the micro farm level and the level of regional water resource development. Regarding the farm level, use of the model points to the optimal irrigation policy, with selection of decision variables depending on the particular situation of the farm. The most meaningful use of the model on this level would be with respect to farms which have a water supply from different sources of varying qualities (e.g., farms in Beisan Valley in Israel). On farms without control of the quality of their water supply, the decision options are restricted to leaching decisions only. Such a case was referred to above.

Regarding the regional level, the model and the empirical estimates obtainable with its aid may be useful in the analysis of water resource development where the parameter of quality is taken into consideration. Water quality has gained increasing attention in recent years in numerous locations in the world [9, 10] due to the gradual process of pollution and quality deterioration of some major natural sources of water supply and the technological possibility to improve quality of water by special treatments such as desalination. A comprehensive analysis of the value of quality of water will be meaningful only if performed within the framework of an actual water demand and supply situation. While such an approach falls beyond the scope of this paper, the possible magnitudes of the "quality premium" to be assigned to desalted water can be pointed out. Consider a hypothetical (but not unlikely) situation of citrus irrigation, 10 to 15 years in the future, in which the MVP of a standard cubic meter of water with chloride content of 8 m.e./l would be 0.20 IL/m^3, (60 $/acre foot). Assume that it will be mixed with one m^3 of desalted water at the ratio of 1:1. In the result two m^3 of water will be obtained with chloride content of 4 m.e./l. On the basis of results presented here, if a quality premium of IL. 0.03 per 1 m.e. Cl/l is assigned, the total value of the two cubic meters obtained after mixing will be IL.0.64, leaving a net value of IL. 0.44 for the desalted cubic meter, i.e. more than twice the standard MVP.

The above only approaches a possible use of the model's results. A comprehensive analysis considering demand for water and the total water supply system should be undertaken to arrive at more specific conclusions about the value of water quality under any specific demand-supply situation. A major consideration in such an analysis will be the relative area of crops, such as citrus, sensitive to salinity.

References

[1] BERNSTEIN, L. *Salt Tolerance of Plants*, USDA Agr. Inform. Bull. 283, 1964.

[2] ———, *Salt Tolerance of Fruit Crops*, USDA Agr. Inform. Bull. 284, 1965.

[3] BIERHUIZEN, J. F., *Water Quality and Yield Depression*, Inst. Land and Water Mangmt. Res., Wageningen, Holland, Tech. Bull. 61 (1969).

[4] BRESLER, E., "A Model for Tracing Salt Distribution in the Soil Profile and Estimating the Efficient Combination of Water Quality and Quantity under Varying Field Conditions," *Soil Science* 104:227–233, Oct. 1967.

[5] ———, AND D. YARON, "Soil Water Regime in Economic Evaluation of Salinity in Irrigation," *Water Resour. Res.* 8:791–800, Aug. 1972.

[6] DEFORGES, J. M., "Research on the Utilization of Saline Water for Irrigation in Tunisia," *Nature and Resources* 6:2–6, March 1970.

[7] Farm Revenue Research Institute, "Profitability of Citrus Industry 1968/9," Tel Aviv, Farm Revenue Res. Inst., 1971, mimeo., in Hebrew.

[8] HOWARD, R. A., *Dynamic Programming and Markov Processes*, Cambridge, Mass., The M.I.T. Press, 1960.

[9] MACAVOY, P. W., and D. F. PETERSON, *Large Scale Desalting*, New York, Praeger Publishers, 1969.

[10] PINCOCK, M. G., "Assessing Impacts of Declining Water Quality on Gross Output of Agriculture, A Case Study," *Water Resour. Res.* 6:1–13, Feb. 1969.

[11] SHALHEVET, J., P. REINIGER, AND D. SHIMSHI, "Peanut Response to Uniform and Non-Uniform Soil Salinity," *Agronomy J.* 61:384–387, May–June 1969.

[12] TIMMONS, J. F., AND M. D. DOUGAL, "Economics of Water Management," *Proceedings of International Conference on Water for Peace*, Superintendent of Government Documents, Washington, D. C., 1967, p. 403.

[13] YARON, D., "Economic Criteria for Water Resource Development and Allocation," II, The Hebrew University of Jerusalem, 1966, mimeo.

[14] YARON, D., AND E. BRESLER, "A Model for the Economic Evaluation of Water Quality in Irrigation," *Australian J. Agr. Econ.* 14:53–62, June 1970.

On the Incongruity of Program Objectives and Project Evaluation: An Example from the Reclamation Program*

DANIEL W. BROMLEY AND BRUCE R. BEATTIE

In public programs project evaluation is often based on an objective that is more specific than the general objectives of the program. In such situations, benefits may be underestimated. The magnitude of this underestimation is assessed for a proposed reclamation project in Southern Idaho.

At the present time over 33 million acres in the 17 western states receive irrigation water provided by the Reclamation Program [14]. While appropriations for the Bureau of Reclamation now stand at approximately one-third of their level 20 years ago (in 1967 dollars), the Reclamation Program still continues. With the recent interest in multi-objective planning and evaluation of water resource projects, it would seem pertinent to investigate the nature of the Reclamation Program, the objective function utilized to compute irrigation benefits, and any incongruity that may exist between the objectives of the Reclamation Program and the concept that gives rise to benefits and costs.

As students of farm policy are aware, much farm-related legislation rests on the assumption that the preservation of the "family farm" is a significant goal of U. S. farm policy. One of the more explicit manifestations of this goal can be found in the Reclamation Program where acreage restrictions limit the size of farms receiving project water. According to Kimball and Castle, the objectives of the Program are:

> (1) to provide opportunities for the maximum number of settlers on the land; (2) to distribute widely the government-involved, interest-free funds for irrigation; and (3) to promote the family farm as a desirable way of life. [8, p. 26]

As was codified in the 1902 National Reclamation Act of the 57th Congress,

> No right to the use of water for land in private ownership shall be sold for a tract exceeding 160 acres to any one individual landowner. . . . [2, p. 252]

In this paper the theoretical basis for benefit measurement as practiced by the Bureau of Reclamation is presented. It is argued that project benefits as computed are less—as a result of institutional constraints—than they would be in the absence of such constraints and are less than they would be if an objective function consistent with the Program's objectives were utilized. Results of a numerical example suggest the order of magnitude of this divergence for a specific Reclamation Project. Finally, the opportunity cost of the "family farm" and implications for project evaluation are discussed.

The Theoretical Framework

The position taken in this paper is that the difference in factor rent accruing to the owners of fixed factors of production (quasi-rent) is a component of direct social cost.[1] If such rents are altered due to the manipulation of a policy variable—in this case, size of farm—differences should appropriately be accounted for in benefit-cost calculus.

Assume a reclamation project involving m new 160-acre irrigated farms. For such a project, one could presumably determine the aggregate derived demand function for water, for example,

$$(1) \qquad P_1 = f(X_1, P_y, P_2, P_3, \cdots, P_n)$$

where P_1 is the price of water, X_1 is quantity of water, P_y is product price, and $P_i (i=2, 3, \cdots, n)$ is the price of the ith factor (excluding the fixed factor land).[2] Assuming the underlying production function is well-behaved (i.e., yields

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[1] For a discussion of the theoretical issues here see Harberger [6].

[2] More precisely, this equation is an inverse demand function; the usual factor demand function expresses quantity as a function of price whereas here price is expressed as a function of quantity. Also, a single-product production process is assumed.

downward sloping factor demand functions) and treating the product price and the non-water-input prices as fixed parameters, a traditional two-space representation such as P_1 in Figure 1 may be specified.

It is hypothesized that the aggregate demand curve for water on a project containing m new 160-acre farms (P_1 in Figure 1) lies below the aggregate demand curve for water if the project is comprised of fewer but larger farms (P_1^*). If the scale of the project is such that X_1° acre feet of water per season can be provided, then the shaded area between the two aggregate demand curves, the ordinate, and the "supply curve" (S) represents the direct annual opportunity cost of designing projects to perpetuate the "family farm," the argument being that this cost is due to delivery of water to farms of less than optimum size. In general, the annual direct opportunity cost of creating family farms by means of the 160-acre limitation is given by:

$$(2) \qquad Z = \int_{X_1^A}^{X_1^{\circ}} [P_1^*(X_1) - P_1(X_1)]dX$$

where Z is annual direct opportunity cost, P_1^* is the aggregate price demand function for optimally-sized farms, P_1 is the same function for 160-acre farms, X_1° is project water supply, and X_1^A is some initial point of integration.

The Bureau of Reclamation's empirical notion of "repayment capacity" is equivalent to the area under the water demand function. The budgeting procedure used by the Bureau to calculate repayment capacity is adopted for purposes of this paper. That is, repayment capacity is calculated as follows:

(1) ascertain crops to be grown on project acreage, yield and price in the economic midpoint of the analysis;[3]
(2) compute gross revenue and gross expenses (net of water charge) per acre;
(3) compute "net farm income" per acre (repayment capacity).

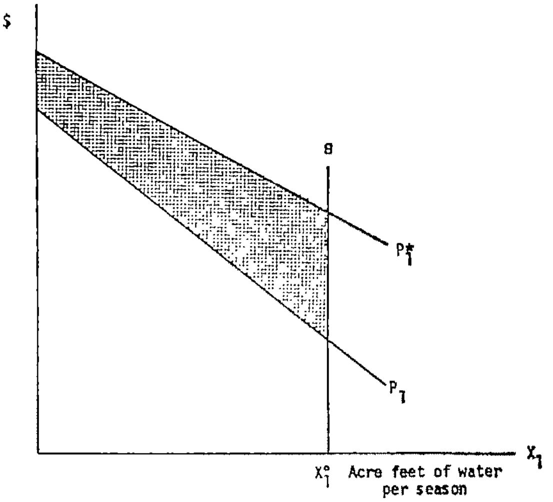

Figure. 1 Hypothesized aggregate demand curves for water under two assumptions regarding farm size

In effect, all factors are costed out of gross revenue, leaving a residual return for management, water, and rent accruing to the fixed factor(s). Because costing of management is an imposing problem in farm management research, the Bureau includes return to management and rent in returns to the residual claimant—in this case, water. Assuming that the quantity and quality of management is not significantly different between 160-acre and larger irrigated farms, then presumably differences in net farm income per acre (repayment capacity) can appropriately be attributed to water.

A Numerical Example

The Mountain Home Division of the Southwest Idaho Water Development Project is a multipurpose undertaking, proposed by the Bureau of Reclamation, that would provide, among other goals, for the establishment of new farming opportunities on 44,405 acres of public land—land that is presently in reclamation withdrawal [3]. Lindeborg [10] has recently investigated the marginal value productivity of water in southern Idaho. The Oakley Fan region included in Lindeborg's study is located close to the Mountain Home Project. Accordingly, Lindeborg's findings are suggestive of the differences in repayment capacity afforded by altering the size of farms in that region.

Repayment capacity information in the Oakley Fan area for 200- versus 600-acre farms is presented in Table 1. Lindeborg found that net farm income for a 600-acre farm was substantially more than triple that for a 200-acre farm—$33,761 compared to $6,093. If new farms of 200 acres were created on public lands in the Mountain Home Division, there would be 222 farms on the 44,405 acres. At an estimated $6,093 of net revenue per farm, total

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[3] This is simply the "halfway" point for the project's design life.

Table 1. Optimum crop combination, net revenue per crop-acre, net revenue per crop, and total net revenue[a] per farm on two farm sizes (Oakley Fan area)[b]

Crop	200 Acre Farm			600 Acre Farm		
	Acres	Per Acre Net Revenue		Acres	Per Acre Net Revenue	
Potatoes	30	$73.58	$2,207.40	140	$100.46	$14,064.40
Sugar Beets	30	10.52	315.60	60	31.34	1,880.40
Grain	80	40.22	3,217.60	280	55.18	15,450.40
Alfalfa	20	−4.94	−98.80	60	8.34	500.40
Beans	35	12.90	451.50	60	31.09	1,865.40
	195		$6,093.30	600		$33,761.00

[a] Net revenues include returns to management and pure profit (rent), as well as return to water.
[b] Source: [11].

project net farm revenue would be $1,352,646. However, if farms of 600 acres were established, there would be only 74 farms, but total project net farm revenue would be $2,498,314. The difference, $1,145,668, represents an estimate of the value of direct output that would be forfeited to create farms of 200 acres in size rather than larger, more efficient farms.[4]

The direct opportunity cost figure is, of course, an annual estimate of income foregone; it is necessary to compute the present value of this opportunity cost over the life of the project. Assuming a 50-year project life and a discount rate of 7 per cent,[5] the present value of direct opportunity cost of the 200-acre versus the 600-acre farm is $15,811,073; for an assumed project life of 100 years the direct opportunity cost is $16,347,824.

Two caveats should be noted in interpreting the figures. First, in actuality, planned farm size in the Mountain Home case is 80–90 acres. Thus, the social cost estimates offered here (based on the comparison of 200-versus 600-acre situations) are no doubt conservative. However, a second caveat tempers this one because, despite intentions of the Congress to create "family farms," history records that the effectiveness of acreage limitations is not long-lived. *Establishment* of small farms on reclamation projects does not insure the *survival* of those farms. Kimball and Castle [8] found that on a project in central Oregon, the 642 planned ownership units were consolidated into 550 by the time water was available to the entire project. Farms less than 40 acres in size decreased the fastest but stabilized in number as off-farm employment opportunities were found. Whereas farms over 160 acres comprised only 4 percent of the original ownership units, within eight years this size class comprised 22 percent of the operating units.[6] If Kimball and Castle's findings are suggestive of what can be expected for reclamation projects in general, then estimates of direct opportunity cost should be reduced accordingly. However, for this example the estimate offered is probably on the low side because of what appears to be a very great divergence between the "planned for" (80 to 90 acre) and "more efficient" sized (600 acre) irrigated farms in southern Idaho.

Implications

While the objectives of the Reclamation Program are recognized as providing for settlement opportunities, perpetuating the family farm, and distributing government subsidies, the objective function employed in project evaluation—and hence the concept from which benefits and costs are derived—is expressed in terms of income potential (willingness to pay). Use of a willingness-to-pay concept when institutional constraints preclude the optimum combination of productive factors results in an incorrect assessment of the full social value of the program; *willingness-to-pay benefits are underestimated* in relation to the productive potential of the site under different organizational rules. This would be appropriate *if* the other nonmonetary benefits which are of relevance in the program were given expression in the evaluation process; however, such is not the case.[7]

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[4] Studies of irrigated agriculture in southern Idaho reveal that most size efficiencies are achieved with a 600-acre operation [7].

[5] The Water Resources Council—in their proposed *Principles and Standards*—advocates a discount rate of 7 percent. There is, of course, a lengthy debate in the literature over this issue, and the Council admits that a rate of 10 percent might be more appropriate. As for the project's life, the Council argues:

> The period of analysis will be the lesser of: (1) the period of time over which the plan will serve a useful purpose considering probable technological trends affecting various alternatives; or (2) the period of time when further discounting of beneficial and adverse effects will have no appreciable result on design. Where pertinent, however, appropriate consideration will be given to long-term environmental factors which may extend beyond periods significant for analysis of effects for national or regional economic development [15].

[6] Because a spouse may hold title to part of the land receiving reclamation water, it is possible for an "operating unit" actually to exceed 160 acres. The extent to which the "160-acre law" has been circumvented is further documented by Taylor [12].

Since many public programs are conceived with the intent of meeting diverse objectives, several suggestions have recently been made for generating and displaying both monetary and nonmonetary impacts from such undertakings [2, 9]. Yet much recent emphasis on multiobjective planning and evaluation has focused attention on ways of measuring benefits in monetary terms for the many disparate types of project impacts [11]. Certainly efforts to obtain monetary proxies for goods and services not now given expression through the market should continue, but it is most important that these investigations first concentrate at the theoretical level to insure conceptual validity.[8] Public programs create monetary as well as nonmonetary outputs, and exclusive concentration on the issue of how to express the latter in terms of the former might be considered by some to be inconsistent with the true meaning of multiobjective evaluation.

A more comprehensive evaluation of public sector activities, including the Reclamation Program, would seem to suggest less emphasis on *benefit*-cost analysis and more on cost-effectiveness analysis. More attention could then be paid to the illumination of the full opportunity costs of, for example: (1) attaining a certain level of water quality; (2) achieving a certain degree of regional development; (3) providing for entrepreneurial opportunity; or (4) attaining a certain income redistributive objective. However, in public sector programs, the issues are rarely this simple. Often decision makers need to know the opportunity costs of achieving several independent objectives. Here one not only analyzes alternative means for achieving each of the several objectives, but in the process of articulating the most cost-effective means, is in a position to illustrate the opportunity cost of achieving one objective *vis-à-vis* others. This process then provides the basis upon which informed judgments regarding tradeoffs can be made.

In summary, the Reclamation Program is a classic example of a multiobjective undertaking, yet the evaluation criteria applied are quite at odds with stated objectives. More relevant for the future is the fact that as research focuses on ways to expand traditional benefit-cost analysis to incorporate nonmonetary impacts, serious conceptual and empirical difficulties will be encountered. A cost-effectiveness approach avoids many of these obstacles, and, of equal importance, may result in analysis that is more congruous with the objectives of public programs.

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[7] The argument here is not that continued public-sponsored irrigation of the arid West is justified on national income grounds; the authors agree with Boulding [1], Tolley [13], and Freeman [4] in this regard.

[8] For similar views, see Freeman and Haveman [5].

References

[1] BOULDING, KENNETH, "The Economist and the Engineer: Economic Dynamics of Water Resource Development," in *Economics and Public Policy in Water Resources Development*, eds. S. C. Smith and E. N. Castle, Ames, Iowa State University Press, 1964, pp. 82–92.

[2] BROMLEY, D. W., A. A. SCHMID, AND W. B. LORD, *Public Water Resource Project Planning and Evaluation: Impacts, Incidence, and Institutions*, Working Paper #1, Madison, Center for Resource Policy Studies, School of Natural Resources, University of Wisconsin, Sept. 1971.

[3] Bureau of Reclamation, *Southwest Idaho Water Development Project*, Boise, 1966.

[4] FREEMAN, A. M., III, "Six Federal Reclamation Projects and the Distribution of Income," *Water Resour. Res.* 3:319–332, Second Quarter 1967.

[5] ———, AND R. H. HAVEMAN, "Benefit-Cost Analysis and Multiple Objectives: Current Issues in Water Resources Planning," *Water Resour. Res.* 6:1533–1539, Dec. 1970.

[6] HARBERGER, ARNOLD C., "Three Basic Postulates for Applied Welfare Economics: An Interpretive Essay," *J. Econ. Lit.* 9:785–797, Sept. 1971.

[7] Idaho Water Resources Board, *Family Size Farms*, Tech. Advisory Comm. Rep., Information Circular 3, Boise, 1969.

[8] KIMBALL, N. D., AND E. N. CASTLE, *Secondary Bene-*

fits and Irrigation-Project Planning, Oregon Agr. Exp. Sta. Tech. Bull. 69, May 1963.

[9] Leven, Charles L., "A Framework for the Evaluation of Secondary Impacts of Public Investments," *Am. J. Agr. Econ.* 52:723–728, Dec. 1970.

[10] Lindeborg, Karl, *Economic Values of Irrigation Water in Four Areas Along the Snake River in Idaho*, Idaho Agr. Exp. Sta. Bull. 513, Jan. 1970.

[11] Maass, Arthur, "Public Investment Planning in the United States: Analysis and Critique," *Public Policy* 18:211–243, Winter 1970.

[12] Taylor, Paul S., "160-Acre Law," in *California Water*, ed. David Seckler, Berkeley, University of California Press, 1971, pp. 251–262.

[13] Tolley, G. S., "Reclamation's Influence on the Rest of Agriculture," *Land Econ.* 35:176–180, May 1959.

[14] U. S. Department of the Interior, Bureau of Reclamation, *Summary Report of the Commissioner*, Statistical Appendix, Parts I–III, Washington, 1970.

[15] Water Resources Council, *Proposed Principles and Standards for Planning Water and Related Land Resources*, Federal Register, 36(245) Part II: 24144–24194, Washington, U. S. Government Printing Office, Dec. 21, 1971.

Environmental Perceptions and Policy Misconceptions *

C. DIRCK DITWILER

Several social institutional states and environmental perception processes are analyzed to ascertain why examination of environmental problems and solutions within a holistic framework often does not lead to expected rational solutions. Implication of these factors for policy analyses leads to the conclusion that such analyses can be improved by expanding the scope of the traditional economic model.

MANY people increasingly concerned about environmental quality have argued the need to examine problems and solutions in a broad context. They plead for a holistic or ecosystems framework,[1] typically defined in terms of the natural and physical elements of the ecosystem. Limited elements of the social sphere are imperfectly laid over this framework. The implication is that man's total environment is intelligible through the rational processes of the physical world. They seek to define an optimum environment from natural laws. The answer, however, does not lie in these laws alone. What is optimal depends upon people's perspectives and values. There is no universal ecologically rational man.

In contrast, some people have questioned the operational effectiveness of the holistic approach to social problems [5, 11]. The typical argument is that although this approach has helped us understand problems, it has done little to generate solutions. That is, new problems emerge when we move from a high level of abstraction and deal with practical issues. The problem extends beyond the difficulty of identifying relevant system variables. It requires changing man to fit the environment. Even so, many people find it difficult to understand why man continues to be "irrational" and why he takes an *ad hoc* or piecemeal approach to environmental problems.

This paper postulates that it is not enough to argue that since connectedness is the essence of all things, an ecosystems analysis will lead to an "objectively rational solution."[2] Rationality in the physical sphere does not automatically lead to rationality in the social sphere. To recognize this, one must better understand man's perception of certain elements of his environment. To do so, it is instructive to look at some social institutional states and some environmental perception processes that often import operational obstacles into conceptually rational analyses.

Many believe that economic analyses can—and should—play a more direct role in forming environmental policy. A better understanding of certain institutional states and perception processes should lead to their explicit recognition in problem analysis. In turn, this should help increase the power of economic analyses in both operational and abstract problems.

The Call for Objectively Rational Action

"Environment" includes many factors, natural and man-made, external to man. Man lives by exchanging matter and energy with his environment. The form and pattern of exchange depends, largely, upon man's social, economic, and technological milieu. Initial relationships with the environment mainly concerned the basic needs of life. However, economic development has brought a significant change in man's relationship to his environment. Now that the basic needs have been met, a new class of more complex demands are being placed on the environment. These demands are often nebulous, intangible, and based largely on subjective perception.

New environmental concerns are gaining visibility through old institutions. As a consequence, the tendency is to focus on physical changes resulting from man's interaction with the environment—e.g., a dam on a river—rather than the impact of such change on man. The character of a river is changed, but the changes are not the reasons why the river is

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[1] A notable recent example is [1]. Elements of economic theory—especially the concept of externalities—as well as ecological theory also clearly suggest this need.

[2] Such a solution implies that man views and understands his world through objective reason applied to scientifically ascertained facts and that he will act according to this understanding.

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used. Man's interest and sense of importance are the reasons. Physical structures are merely the outcome of the existence of the river and man's special interest in it. However, the focus on man-made attributes creates the tendency to think about and analyze man's activities in terms of these attributes. Thus, means (inputs) tend to assume the role of ends (outputs).

The process has been institutionalized in many governmental agencies where missions are typically defined on an input basis—e.g., forests, soils, irrigation dams, and flood control projects. Thus, it is difficult to develop a holistic attitude toward the contributions of integrated activities.

In a democracy individuals or special interest groups usually seek to accomplish goals within pertinent political and legal institutional structures. The structures establish rules of the game for the interest groups, and policies emerge as elements of these structures. Certain characteristics of the institutional structures tend to lead to fractional problem definition and problem solution. Input orientation of agencies and interest groups leads to partial and incorrect problem definition.

Lack of correspondence between the jurisdictional boundaries of agencies and the real boundaries of an environmental problem also results in incomplete problem definition. At the same time, solutions to defined problems tend to be fractionalized. This occurs because programs designed to combat environmental degradation are generated within the political sphere, where programs typically represent compromises reached in an attempt to balance interest among various groups. Balancing gives the conflicting parties a slice of the pie, even though it may not satisfy their originally defined interests.

The above factors cause man's view to remain myopic and his perception narrow, even though his aggregate concern for the environment has broadened. As a partial result of this myopic perception, increasing pressure of man's activity upon the environment over time has recently reached a visible level. Individuals reacting to narrowly defined and seemingly independent interests created environmental degradation to such a degree that a social problem emerged.

A social problem has been defined as "... a condition affecting a significant number of people in ways considered undesirable, about which it is felt something can be done through collective action" [6]. It is apparent that "something" can be done through collective action. Numerous new programs have been started and resources committed to combat environmental degradation, although many of the programs are considered to be failures. The general ineffectiveness of past programs has led people to view the systems framework of problem analysis (and the objectively rational basis for action that it presumably generates) as a panacea.

Obstacles to "Objectively Rational Action"

As suggested above, some factors prevent the transfer of rational processes from the physical to the social sphere. These factors, although related, can be discussed under two categories, social structure and environmental perception.

Social structure

Social conformity and growth.—Conformity in perception and conformity in action form a self-reinforcing feedback system. When society was simple and man's needs were basic, conformity was high and man interpreted human action on the model of nature. As society developed and became more complex, it became apparent that human society differs appreciably from nature. Human activities are discretional at a subjective level, and the motives behind many activities are highly varied. As human societies evolve, psychological needs become more important relative to biological needs. Thus conformity becomes less frequent. In the attempt to achieve order, if not conformity, informal and formal codes of social relations are developed. This increases the complexity and heterogeneity of the social structure and results in an expanded range of interest and fractionalized institutions.

Man uses these codes hoping to achieve "acceptable" and reasonably predictable action patterns or order in his relationships with other men and with nature. An example of an informal code is the exhortation from Earth Day activities designed to instill a sense of social environmental consciousness and concern in the minds of the general public. It was argued that it is in the public interest to be environmentally concerned.

A notable example of a formal code or law is the National Environmental Policy Act of 1969 and the several state laws cast in its mold. Widespread use of formal codes in the U. S. makes it useful to look at the relationship between law and interests reflected by various publics.

It has been stated that "men legislate . . . not in accordance with their opinion as to what is good law, but in accordance with their interest . . . " [4, p. 12]. Some argue that the law can only be out of step with the public interest in the short run. Others view law as a positive force that may influence interest and thus may be used as an instrument to effect social change.

The apparent decisiveness of law implies the existence of a well articulated social welfare function. If such were the case, laws would have potential to control conflicts. For example, as the ability to predict environmental effects of new technology is perfected,[3] law could be used to moderate the differential impacts of new technology before a crisis and attendant vested interests developed.

However, ample evidence shows that social goals are usually multi-faceted, dynamic, evolutionary, and often conflicting. Thus there is no master plan to guide legislative action. Even if such a guide existed, social consensus on appropriate decision criteria and institutional structure would be required. To this extent, a critical social problem is not reduced or eliminated; problem elements are left essentially unchanged, their sequence in the social decision process being merely altered.

Social conflict and institutions.—As society has grown more complex, the potential for short-run conflict has increased significantly. An environmental quality control program may benefit nearly everyone in the long run. In the short run, it generally will have significant differential impacts. These conflicts provide the rationale for a systems approach, since such an approach presumably can suggest solutions by clearly identifying the existence and nature of the competitive relationships.

However, as new dimensions and different elements of old dimensions are made visible, problem solving may become more, not less complex. Increased visibility may increase conflict and perhaps cause a stalemate, depending upon the relative strengths of interest groups associated with the dimensions and the effectiveness of conflict resolution modes.

Since environmental conflicts are largely resolved through the political process rather than by planners, the onus of change falls on political institutions. Failure to provide effective institutional structures within which conflicts can be reconciled will likely block the practical application of the ecosystems approach, since this failure will result in an increased number or intensity of unresolved conflicts. Increased resort to the courts reflects the inadequacy of existing institutional structures or informal codes. There is little room for optimism, since organizational reform of governmental institutions is very difficult and slow. Further, it is unlikely that the constitutional protection afforded free thought and speech and individual rights will be reduced much.

Social perspective and science.—Concern for environmental quality has grown as more of man's requirements for subsistence have been met. Today there appears to be an increasing concern for a new humanism and aesthetics and less concern for materialism and primary utilitarianism. Increased concern for aesthetics has occurred at a time when science has proved its ability to help improve the human condition.

It is apparent that science itself has significantly affected man's perspective. Subject matter specialization has increased significantly as science has matured. As a result there has been a general reduction in an individual's scope of perception. As additional fields of specialization are defined and mature, internal rigor replaces external connections and dependence.

The distinction between logic and aesthetics made by Whitehead [12] suggests that concern for the latter implies the need for a broad scale of perception and a concern for external composition. To the extent science utilizes logic, it focuses on abstraction. Logic starts with detail and moves to abstract construction. Aesthetics moves in the opposite direction. The whole precedes the detail; the details emerge only as reasons for the whole. Thus, attempts to apply the logic of science may partially frustrate efforts to recognize and understand aesthetic dimensions of the environment.

Intrinsic basis of perception

It was argued above that man's regard for the environment has evolved from a concern with relatively simple physical elements to a concern with more complex, less tangible elements. As a consequence, the psychological phenomena of perception of the external environment have become more important. In general, little is known about environmental perception,[4] and in particular no attempt has been made to examine its impact on problem analysis and policy prescription. This section offers a framework for viewing certain environmental perception elements and understanding their implications for policy analysis.

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[3] For a discussion of technology assessment see [2].

Matter-of-fact and importance have been distinguished as the two basic elements that underlie all human experience [12]. The former involves the notion of mere existence and is the basis of importance only because "something" has to be important. In turn, importance is a necessary condition of matter-of-fact. Out of a sense of importance certain facts rather than others are perceived. Without this sense the existence of a fact would be observed and discarded as being inconsequential.

But, "a single fact in isolation is the primary myth required for finite thought. . . . This mythological character arises because there is no such fact. Connectedness is of the essence of all things. . . . Abstraction from connectedness involves the omission of an essential factor in the fact considered . . . " [12, pp. 1–13]. It follows that when facts are considered for thought or analysis, one must necessarily abstract from many elements that link the facts to their milieu. Milieu is the relevant system in its relationship to the facts. Linkage between facts and their milieu is the critical element in the emergence of a particular perspective.

Principal elements in this paradigm are man the perceiver, facts, milieu, the linkage between facts and milieu, and the resultant perspective. In what follows, several characteristics of the decisive linkage factor will be examined. These include sense of importance, the nature of conceptions, and scope of perspective.

Sense of importance.—Acceptance of the importance of the linkage factor implies an exhaustive view of the universe. Such a view is denied man because of his finite mind. Nevertheless, man understands things in terms of *some* dimensions. For comprehension, man reduces the potentially infinite number of perspectives to a manageable set. At the conceptual level, no perspective has to be eliminated. However, a sense of importance determines which perspectives will dominate. Judgments about importance dictate the approach taken to a problem and thus eliminate many perspectives. This is often an unconscious elimination, since an approach determines what will be included without much thought to what will be excluded.

Sense of importance reduces perspective further. Since man has a limited capacity to command facts at a given time, importance is usually determined by the elements of a visible but often only implicitly defined objective. Specific objectives serve to identify the "best" perspective from the remaining number of possible alternatives.[5] Given this, it is instructive to examine some internal and external factors that influence formation of a sense of importance.

An obvious internal factor consists of the aggregate of elements that make up the initial state or disposition of the perceiver. This set of elements includes, for example, past experience, knowledge, values, beliefs, and organizational and personal commitments. Objective visibility is another important internal factor. This is largely defined by *felt* (and to a lesser degree, anticipated) impacts of the existence or change of some factor in the environment. Since environmental degradation often involves benefits and costs borne by different groups, sense of importance to a given group may be restricted even further.

External factors have an equally important impact on the formation of objectives, though often ignored. Such factors tend to move concerns from abstract principle to practical issue. One important external factor is the articulated or anticipated objectives (and thus perspectives) of other groups relevant to a problem situation. Another is the institutional structures (largely political and legal) through which objectives must be sought.

Implications of the above discussion are many. It is apparent that there are few common denominators in the development of a perspective. There are no normalized choice criteria such as those generated by the market in the economic sphere. The internal visibility factor coupled with the two external factors mentioned suggests that objectives are dynamic functional concepts. They are not automatic but emerge out of an interaction of factors. This helps explain the superficially contradictory positions often taken by interest groups (e.g., conservation groups) on a given environmental issue in different places or times.

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[4] However, for some interesting insights see [7] and [9].

[5] The correspondence between this paradigm and the production possibility model of economic theory is apparent only. There is no reasonable counterpart to market generated choice criteria for determination of an unambiguous "best" position.

This discussion also helps one understand the effect of a restricted conception of relevance imposed by, for example, a focus on inputs or physical change rather than on outputs or social impacts resulting from change. Although, conceptually, nothing prevents several alternative perspectives consistent with a particular objective from being identified, a focus on inputs often precludes such an outcome. Note the difficulty the Corps of Engineers experienced in recognizing nonstructural means of providing flood protection.

The nature of conceptions.—The abstraction from connectedness required for understanding also tends to lead to static conceptions where problem elements are viewed in a static physical, spatial, and temporal structure. This in turn leads to the tendency to view the fact-milieu couplet in terms of static attainment. This view suggests that the existing structure constitutes an immutable constraint and thus is infinitely costly to alter.

In contrast, the dynamic view is couched in terms of attainability. However, the focus often uses future static states as desired end products. Effort is thus concentrated on defining alternative states in terms of—perhaps Pareto—optimal conditions. Little thought is given to how to make the move from the present to the future state and whether the change itself meets criteria for optimality. The latter point is ignored when the analytical model used conceives policy planning as an abstract, objective process. Most traditional economic models do just that.

Sometimes an attempt is made to introduce a dynamic dimension into facts conceived within a static framework. In such cases, the future is projected in terms of the present static state. Often the practical end result of this approach is to assure continuance of a present perhaps undesirable state since future needs are planned and provided for on the basis of such projections.[6]

Scope of perspectives—Man's point of view influences the nature of his reaction to the environment. Well defined points of view are essential for understanding and for scientific method, but they are not costless. Abstraction from connectedness permits clear classification; it also renders any point of view "relevant" since each part becomes a whole or an "end." Points of view involve the notion of composition and range between two polar positions—internal and external composition [10, 12]. Internal composition refers to the thing itself. Analysis at this scale makes evident why the thing is what it is. An example is the conception and analysis of the water resource at the molecular level.

In contrast, external composition involves conceiving the thing as a unity and focuses on its relationship to other elements of its environment. An example is the conception of the water resource in terms of units of flow capable of transforming or being transformed by the adjacent environment.

Abstraction from connectedness in a general way diverts sense of importance away from the interfaces between classes. Inquiry at these interfaces thus tends to be difficult to carry out and difficult to sell. Even when two subsystems (say S_1 and S_2) are recognized as being serially linked, the tendency remains to view the output boundary of S_1 as the decisive information mechanism for the system rather than the input boundary of S_2. This helps explain why certain water quality programs focus on water quality *per se* with little reference to water usage and result in program confusion and inefficiency [3].

A problem also exists when an attempt is made to relate essentially similar points of view from different environmental dimensions. For example, the physical regimen of a water course may become more clearly defined as it is traced from a reach to a watershed to a river basin. However, the fact that a problem is analyzed within the context of a river basin rather than a small reach of the river does not imply that social or economic understanding will increase. Things are often not what they seem; there exists a fallacy of composition. Physical rationality does not necessarily lead to social rationality.

Conclusions

The general complexity and pervasiveness of environmental quality problems has led many people to conclude that rational solutions can be generated only by using a systems approach to problem analysis. The typical approach is to build systems models based primarily on physical parameters and to treat elements in the social sphere as being intelligible through the same rational processes as applied to the physical sphere.

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[6] For an example of how such demographic projections can adversely affect population policy and thus environmental quality, see [8].

It is acknowledged that a holistic approach can help to identify competitive relationships relevant to environmental degradation problems. However, operational solutions within a fundamentally democratic social context require explicit recognition of something more than what is required for a synoptic rational deductive solution. Several social institutional elements and psychological perception elements were identified as leading to an *ad hoc* or piecemeal perspective at the operational level and thereby running counter to the rational holistic perspective generated within the conceptual framework.

A principal conclusion is that one can expect a diversity of perceived "rational" perspectives and thus solutions to environmental problems. There will continue to be a wide range of opinion on environmental problems with continuing and even increasing discord among competing groups.

There is little reason for optimism about the development of a unified public interest with respect to the environment. Public interest is actually a multiplicity of private interests. Each is typically narrow in scope and has a specific public behind it. Recent federal and state agency effort to increase public participation in resource and environmental planning will likely do more to democratize the planning process than to generate objectively rational bases for environmental policy decisions.

The potential for conflicting perspectives increases more than proportionately with the number of interests reacting to specific problem elements. The explanation of this conflict is usually put forth in terms of the "fact" element. That is, it is usually concluded that if people knew the facts, conflict would disappear. This is the rationale for a public participation/education program. However, discussion of the fact-milieu couplet plus the associated linkage factor suggests that clarification of "the facts" need not lead to harmony. *Relevant* facts are perspective specific, and there is no single, rational perspective based on "the facts."

A real need is to help achieve unanimity without strict conformity. An ideal economic market system generates such a result. Environmental decisions, however, are not generated within such a system. Many economists have concluded that relevant social institutions should be transformed to correspond to an idealized market structure or at least they should be modified to yield market-like solutions. Thus, in effect, what was once a means becomes an end. Resistance to such envisioned social structure changes suggests that the potential cost of efficiency as an end is quite high to those affected. Cost is in terms of other highly valued private and social means and ends. An element of cost also falls on the advocates of efficiency to the extent that their concerns receive only meager consideration in practical policy prescriptions.

This suggests that economists could benefit from considering a perspective different from the one generated from the traditional, rather limited market-oriented perspective. Such a perspective would entail direct inquiry into traditionally defined, irrelevant, but practically inextricable elements in the social institution and psychological perception dimensions discussed in this paper. This would involve the development of a theory of choice and conflict resolution outside the assumption of a well functioning market structure. It would involve inquiry into many presently gray areas, including extra-market values, individual and social value theory, interpersonal (group) comparison problems, oligopolistic strategies, and positive sum games. Further, the refinement of an operational and analytical institutional economics appears to hold considerable promise as well as the possibility of increased inquiry at the interface between economics and other disciplines including psychology, sociology, political science, and ecology.

Some will argue that economists have no particular expertise in these areas and therefore should not venture outside the traditional boundary. However, in relation to many other disciplines, economics has a broad and well articulated theory and fairly well refined tools that could prove useful in extending existing knowledge for the solution of many environmental quality problems.

References

[1] CALDWELL, LYNTON K., "The Ecosystems as a Criterion for Public Land Policy," *Natural Resour. J.* 10:204–221, April 1970.

[2] Committee on Science and Astronautics, U. S. Congress, House of Representatives, *A Study of Technology Assessment*, Washington, U. S. Government Printing Office, 1969.

[3] Comptroller General of the United States, *Examina-*

tion into the Effectiveness of the Construction Grant Program for Abating, Controlling, and Preventing Water Pollution, Washington, D.C., 1969.

[4] DICEY, A. V., *Law and Opinion in England*, London, Macmillan and Company, 1914.

[5] HOOS, IDA R., *Systems Analysis of Social Policy*, Westminister, The Institute of Economic Affairs, 1969.

[6] HORTON, PAUL B., AND GERALD R. LESLIE, *The Sociology of Social Problems*, New York, Appleton-Century-Crofts, Inc., 1960.

[7] *Journal of Social Issues* 22 (4), Oct. 1966.

[8] National Goals Research Staff, *Toward Balanced Growth: Quantity with Quality*, Washington, 1970.

[9] PROSHANSKY, HAROLD M., *et al.*, eds. *Environmental Psychology: Man and His Physical Setting*, New York, Holt, Rinehart and Winston, Inc., 1970.

[10] RIPLEY, S. D., AND H. K. BUECHNER, "Ecosystem Science as a Point of Synthesis," *Daedalus* 30:1192-1198, Fall 1967.

[11] SCHLESINGER, JAMES R., "Systems Analysis and the Political Process," *J. Law and Econ.* 11:281-298, Oct. 1968.

[12] WHITEHEAD, ALFRED NORTH, *Modes of Thought*, Cambridge, Massachusetts, The University Press, 1938.

A Short-Run Price Prediction Model for Eggs

Bill R. Miller and Gene C. Masters

The volume of eggs traded in open markets is extremely small relative to total volume of eggs produced. One result has been criticism that current price quotes are formed from insufficient information. The model presented here projects a current quote based on information from a national sample of producers.

After World War II the egg industry began an evolution that rapidly moved its marketing structure away from use of terminal markets where many buyers and sellers could discover price. Many integrated firms now move eggs directly from farm to retail store. Large volumes of trading take place in private negotiations that furnish no price information to the industry concerning the forces of supply and demand.

As a consequence, price quotations based on trade in the New York Mercantile Exchange or based on private quotations of trade in terminal and other markets were criticized as being formed from insufficient information and were, therefore, subject to manipulation. The problem of collecting data from the Exchanges was expressed most succinctly by the Urner Barry Company in its effort to remain the prime source of price quotations: "By checking on buying interest, offerings and mainly by willingness to pay premiums or willingness to reduce premiums or discount we acquired an indication of value in addition to the trading on the Mercentile Exchanges. While this enabled us to better determine our quotations, the process has deficiencies. Mainly it is a dialogue between two people and only the reporter has the complete picture. It is not possible to appraise all of the entire input and indeed the reporter wishes at times to protect his sources of information. Consequently, there is mistrust or lack of understanding at times because all cannot see exactly what provided the background for that particular day's market, or market trend" [4].

Criticism reached a peak following the closing of fresh egg trading on the Chicago and New York Mercentile Exchanges in April 1970. Many egg producers felt that egg trading on the Exchanges was used primarily for the purpose of influencing egg price quotations.[1]

Long before the close of fresh egg trading on the Exchanges, egg producers began to organize in an effort to increase marketing efficiency. One of the first efforts came when egg producers in the Southeast formed the National Egg Company in 1966. One of the primary functions of the organization was to exchange eggs between producers in the region to prevent an unnecessary flow of eggs to the northeastern market where they would have a depressing influence on prices. In 1968 United Egg Producers (U.E.P) was formed to represent egg producers on a national basis. In addition to National Egg Company, this organization included five other regional organizations.[2] Thus it was possible for a group of egg producers to have unified voice in dealing with marketing problems.

Research in the construction and use of a producer's price series and in price projection for U.E.P. members was begun early in 1970. The National Egg Price Study Committee suggested in May 1970 that Urner Barry combine information with United Egg Producers to avoid duplication and improve the pricing system. This paper describes the U.E.P. system and presents an analysis of the theoretical framework and effectiveness of the system in projecting prices.

A Theoretical Supply and Demand Framework to Explain the Dynamics of Price Determination within a Current Trading Period

Supply

Fresh commodities such as eggs are perish-

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[1] An excellent review of egg pricing is presented in [3] in which Rogers comments on the study reported here, "Statistical models, coupled with automated data handling, give promise for improving short-run price prediction and minimizing reliance on subjective judgment in determining base price quotations. With the notable exception of the United Egg Producers, there has seemingly been a great reluctance on the part of the industry and private and public agencies to make use of predictive models."

[2] Members of United Egg Producers were: (1) Northwest Egg Producers, NWEP; (2) Western Egg Company, WECO; (3) Southwest Egg Producers, SWEP; (4) Midwest Egg Producers, MWEP; (5) National Egg Company, NECO; and (6) Northeast Egg Marketing Association, NEMA.

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able and as such may be expected to have an inelastic supply response within some period. Within a trading period of three to five days, however, more elastic supply curves are the expectation for the following reasons:

1. Within three to five days, fresh eggs are easily placed in storage so that suppliers do have options to offer more or less at the same or small changes in price. Furthermore, inventories are not likely to be depleted within this short period.

2. Because of uncertainty, the price discovery process takes time. Eggs not moved in normal channels cannot easily be diverted to terminal or other markets, and price may stay at a given current level for a time while sellers explore alternatives. At the current level, suppliers usually try to satisfy the current needs of buyers. Even though amounts demanded are somewhat greater or less than expected, they are likely to be filled at small changes in price simply as a means of maintaining good relationships and a steady flow of trade over the long-run.

The supply curve in question represents the offer of the supplier to fill orders of varying amounts at his expectation or understanding of the current market price. This behavior is expressed quantitatively in Equation 1. The structural form of a similar supply function has been used in several previous studies (see [1, 2]). In Equation 1, quantity offered, q_{st}, in the current period is a function of current expected price X_t^*.

$$q_{st} = B_o + B_1 X_t^* + \mu_t \tag{1}$$

where $t = 1, \cdots, T$.

$$X_t^* = B_2 + \alpha(X_t - X_{t-1}) + X_{t-1}. \tag{2}$$

The second equation is behavioral in that it defines expected price to be equal to price in the previous period corrected by a constant B_2 and the coefficient, (α), multiplied by the change in current market price from the previous observed price.

Demand

In the very short run the demand for eggs, as well as for many food commodities, is expected to be inelastic. Current consumption of staple items such as eggs is dependent on habits and customs not easily altered by day to day price changes. On a given day the consumption of eggs is likely to be constant over the range of price changes ordinarily observed. Thus, for a price projection model in the very short run, demand may be assumed to be exogenously determined by forces other than those that determine current market price.

Although exogenously determined, demand or q_{dt}, is an unknown quantity to suppliers in the very short run and is a principal source of uncertainty in determining the offer price, X_t^*, consistent with the current supply. Given Equation 2, X_t^*, and thus q_{st} could always be determined exactly except that X_t is simultaneously being determined by the behavior of sellers interacting with an unknown current amount demanded. That is, in forming his expected offer price, the seller must simultaneously form an expectation about current quantity demanded by buyers, q_{dt}. He expects in determining an offer price that q_{dt}, or market demand, is equal to q_{st} which is the quantity he will supply at the expected offer price, X_t^*. However, q_{dt} is not known with certainty until the end of the current period so that an expectation must be formed about the exogenous level of q_{dt}. If this expectation is called q_{dt}^*, the following structural model of equilibrium expectations and market price can be formed.

$$q_{st} = B_o + B_1 X_t^* + \mu_t \tag{3}$$

$$X_t^* = B_2 + \alpha(X_t - X_{t-1}) + X_{t-1} \tag{4}$$

$$q_{dt} - q_{st} = 0 \tag{5}$$

$$q_{dt}^* - q_{dt} = 0. \tag{6}$$

The variable q_{dt} is not ordinarily known during the trading period, and q_{dt}^* is not observable. What is observable, and often quoted in the egg industry, is the estimated difference between expected demand and the current demand being served. This difference, LS, will be positive or long when expected demand is greater than actual demand and negative or short when expected demand is less than the actual demand that occurs in the current period. Thus

$$q_{dt}^* - q_{dt} = LS \quad \text{or} \quad q_d = q_d^* - LS. \tag{7}$$

The same forces that exogenously determine q_{dt} in the very short run are at work on the seller to determine q_{dt}^*; therefore, LS is an exogenous variable that is observable, and Equation 7 may be used to replace the unknown q_{dt} in the structural system of equations. The system thus becomes:

$$q_{st} = B_o + B_1 X_t^* + \mu_t \tag{8}$$

$$X_t^* = B_2 + \alpha(X_t - X_{t-1}) + X_{t-1} \tag{9}$$

$$(q_{dt}^* - LS) - q_{st} = 0. \tag{10}$$

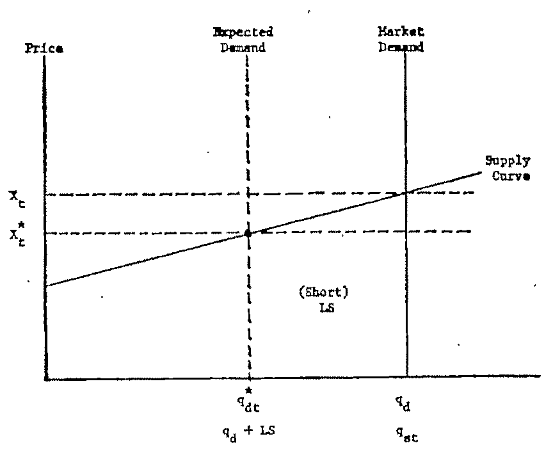

Figure 1. **Price determination within a current trading period**

If LS is zero in this system, then $q_d = q_d^* = q_{st}$, and the actual price that occurs in the present period will, in fact, equal the expected price. The supplier will have offered a price and a quantity just consistent with what the market was willing to take. Current price is thus endogenously determined by interaction of current expectations, the behavioral offer curve, and inelastic demand as shown in Figure 1.

In Figure 1 the expectations of price and market demand are obviously not in equilibrium. Finding that $q_{dt} - q_{dt}^*$ is not equal to zero, the supplier is short, given the offer price of x_t^*; but because of short-run flexibility in controlling supply, he will offer additional supplies, LS, to meet the current demand and will bring offer price X_t^* up to X_t. Long situations will likewise indicate lack of equilibrium in expectations and are given an inverse interpretation.

The system of equations in (8), (9), and (10) thus contains three endogenous variables, q_{st}, X_t^*, and X_t whose equilibrium values are determined simultaneously. The reduced form equation for X_t becomes a price prediction equation in which current price is a function of current expected quantity demanded, last period price, and long-short positions in the current period.

$$(11) \qquad X_t = f(q_{dt}^*, X_{t-1}, LS).$$

Equation (11), however, leaves much to be desired as a price prediction equation as it contains both q_{dt}^* and LS on a current basis. Apparently, current prices are difficult to predict for the same problems of incomplete knowledge that give rise to the requirement for expectations by sellers in the structural model.

The approach taken in this study was to create an information system with sufficient coverage of the market and with sufficient speed that it would yield data on LS sufficient enough to be called current and would also yield accurate weighted average values of X_{t-1} at the farm level. If sample data can be gathered and compiled on a current basis, then perhaps estimates from the reduced form equation describing current price will be reliable as a measure of predicting the current level of price before it becomes apparent at the end of the current period. Sampling, rapid relay of data by telephone, and instant analysis by a simple computer program are thus the ingredients of a short-run price projection program.

The Egg Price Projection Program

Price analysis and projection were made using a program stored on a small remote computer terminal. Logic and use of the program are defined as follows.

Sample data were received by telephone from the central office of United Egg Producers. The most recent producer price and quantity moved at that price were obtained from a sample of producers and handlers in each of six major egg producing regions, Figure 2. Producers and handlers supplying the data from U.E.P. are estimated to furnish 50 percent of the supply of eggs in the U. S. Sample data received were (1) the previous week's prices and quantities for large, medium, and small eggs, F.O.B. at farm, without packing materials, and (2) the long or short position of each region on the day reported for large, medium, small sizes, nest-run gradable current receipt eggs, and nest-run ungradable current receipt eggs. Each U.E.P. regional office was requested to assemble information. It was felt that regional offices would be close enough to producers both to obtain the information and to check its validity. The sample included both large and small producers and covered the geographical areas of the region as uniformly as possible. Regional managers were given the responsibility of verifying that the net surplus or shortage position reported represented the net result of actual bids to buy and offers to sell the product. Regional offices were instructed to check the accuracy of prices reported to them by observing to see if any

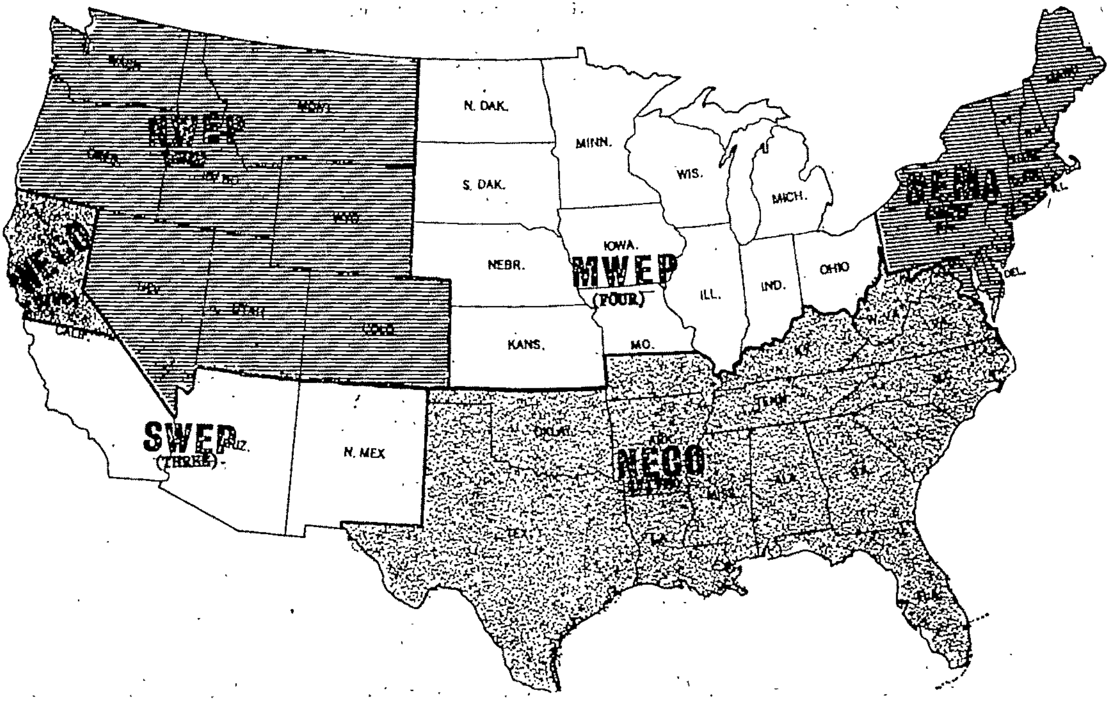

Figure 2. Regional Egg Marketing Cooperatives that were members of United Egg Producers in 1971

prices appeared to be out of line with what was expected and by checking with both buyers and sellers to verify the accuracy of reported prices.

The first calculation on the data was the weighted average price received in each region. On the assumption that consumption per region was directly related to population, the populations of Regions One, Two, and Three were used as weights to calculate western sectional average prices per sizes of egg.[3] Populations in Regions Four, Five, and Six were used as weights to calculate the eastern prices.[4]

Sectional prices were the basic series of prices used in linear regression analysis of the reduced form, Equation (11), and were the lagged prices used in price projection. In August 1970 the reduced form projection equations were estimated as shown in Table 1.

The relatively high R^2 values and significant regression coefficients in the reduced form equation supported the hypothesis offered by the structural equations. Also, the signs of the coefficients relating past period price and long-short positions to current price were the same as would be expected in an *a priori* examination of the model. Signs of regression coefficients for past period price were positive in the equation for both East and West sections, and the signs of long-short were negative in both equations. The coefficient of long-short was not significant in the West, but this may have been associated with the possibility of dumping long positions into military and Eastern markets.

Predicted prices per section were used to predict prices per region on the assumption that regional differences in current prices would prevail; i.e., in the very short run no structural changes were expected between regional market areas. Therefore, the difference between current sectional price and current price in each of its regions was calculated, and the predicted regional prices were the predicted section price plus or minus the last observed differences in weighted average prices.

Finally, the national average price was predicted as the weighted average price of East and West sectional prices. Again, population was the weighting factor.[5]

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[3] Percents of West Populations as Weights in Regions One-Three were: Region One weight, .3107; Region Two weight, .3051; Region Three weight, .3842.

[4] Percents of East Populations as Weights in Regions Four-Six were: Region Four weight, .3402; Region Five weight, .3742; Region Six weight, .2856.

[5] The proportion of population living in the western section was .177; the proportion living in the east was .823.

Table 1. Price projection equations for shell eggs at farm level[a]

Section and Egg Size	Regression Coefficients of Explanatory Variables				
	Constant Term	X_{t-1}	LS	R^2	S.E.
		(cents/doz.)	(000 cases)		(cents/doz.)
East—Large	2.917	.9393 (23.7)[b]	.8066 (3.56)	.96	2.0
East—Medium	2.797	.9234 (25.1)	.9008 (3.80)	.96	2.2
East—Small	2.165	.9075 (23.3)	1.2890 (2.24)	.96	2.2
West—Large	2.001	.9361 (18.5)	.0767 (1.01)	.93	2.7
West—Medium	1.593	.9228 (19.2)	.0556 (0.39)	.94	2.7
West—Small	1.159	.9243 (25.1)	.8547 (1.68)	.96	2.0

[a] Based on 27 weekly observations, Spring 1970.

[b] Numbers in parentheses are "Student's" *t*.

Performance of the Model

The reduced form projection equations did not contain current expected quantity marketed as an independent variable on the assumption that this data cannot be collected on a reliable basis. Thus, including only previous period prices and current long and short data will introduce a specification bias. In the reduced form for X_t the coefficient of q_{dt}^* is $1/\alpha_1 B_1$. Thus, on the assumption that α_1 and B_1 are greater than zero, the absence of the variable q_{dt}^* from the reduced form should impart a negative bias to the projection as its positive effect is not considered in estimation.

Empirical analysis verified that prices predicted by the model were significantly less than prices collected from firms in the sample. The average predicted price in each series among 18 sets of data was in every instance lower than the average price that actually occurred (Table 2). Data in Table 2 represent approximations to the amount of downward bias that existed at the mean. The mean of all prices predicted for medium eggs was significantly different from prices occurring, as were mean prices of large eggs in Regions One, Three, and Five.

In some instances the projected prices did not meet structural requirements that might characterize a multiproduct regional trade model for eggs. For example, prices in other regions of the country set limits on the extent of price change in any one region. The price of one size also acts as a restriction on price changes of other sizes of eggs as prices are not completely independent. Thus, even if there is a shortage of medium eggs and a surplus of large eggs, medium eggs would not be sold at

Table 2. Amount that actual average price in the 42 week prediction period exceeded average predicted price in six regions for large, medium, and small eggs, August 1970 to May 1971

Egg Size	Region					
	One	Two	Three	Four	Five	Six
	(cents per dozen)					
Large	.47*	.51	.23*	.15	.22*	.41
Medium	.67*	.67*	.62*	.50*	.80*	.67*
Small	.51	.60	.47	.02	.21	.05

* Average predicted price was significantly different from price occurring by use of "Student's" *t*-test.

higher prices than large eggs because of the possibility of substitution for many uses. Prices of large and medium eggs seldom move closer than four cents apart. Prices in one region should also be limited from going below the price of the same product in another region less transfer costs. Table egg prices should also be restricted from going substantially below the value of the same product for breaking purposes. These concepts were applied *ex post* to the reduced form estimates in recognition that a more appealing approach for future work would be to incorporate them into the initial structural model.

Summary and Conclusions

Despite the fact that there was supporting evidence for the structural hypothesis, the standard errors of estimate of two to three cents in the projection equations are too high for good prediction. Additional work is needed to create a model that examines effects of seasonal production and inventory on the supply curve of marketing cooperatives and the marketing margin relating farm price to prices of graded and packed eggs. Furthermore, the structural model should be more complete with respect to substitution among egg sizes, competition with egg breakers, and equilibrium among trade regions. But finally, the standard errors are measured with respect to a price quotation system still subject to criticism. If prices are in any manner a function of the present system of quoting prices, then it is doubtful if the model can be improved.

References

[1] GRILICHES, ZVI, "The Demand for Inputs in Agriculture and a Derived Supply Elasticity," *J. Farm Econ.* 41:309–322, May 1959.

[2] NERLOVE, MARC, AND WILLIAM ADDISON, "Statistical Estimation of Long-Run Elasticities of Supply and Demand," *J. Farm Econ.* 40:861–880, Nov. 1958.

[3] ROGERS, GEORGE B., AND LEONARD A. VOSS, eds., *Readings on Egg Pricing*, Coll. of Agr. MP240, University of Missouri-Columbia, Dec. 1971, p. 12.

[4] Urner Barry Company, speech presented in Atlanta, Georgia, May 1970.

United States, European, and World Demand Functions for Coffee*

A. Parikh

Import demands for coffee are estimated with single and simultaneous equation techniques for the United States, Europe, and Rest of the World. Predictions were made for the years 1969, 1970, and 1971 with the help of estimated relations; the predictions were compared with actual world import demands for these three years.

In the present paper estimates are presented for a series of coffee import demand functions based on quarterly data for the 1958–1968 period. Annual import demand functions for the United States are attempted, and similar functions are estimated for the imports of coffee by Europe[1] and the Rest of the World. Also, world imports of coffee are separately estimated from a world demand function. Variations in import demands for coffee in the United States are explained by variations in inventory demands, and income seems to play a negligible role in determining coffee consumption.[2]

Single Equation Models of U. S. Demand

The import equations are of the simple form:

$$(1)\quad \log I_t = a + b_1 \log S_t + b_2 \log P_{wt} + \log U_t$$

where I_t is the total imports of coffee for the United States expressed in terms of quantities (tons), S_t is the level of stocks or inventory holdings at the end of the quarter reflecting the demand for inventories, P_{wt} is the average import unit values[3] constructed on the basis of monthly data for the quarters, $\log U_t$ is the stochastic disturbance variable and was assumed to be normally distributed with zero mean and finite variance, and b_1 and b_2 are the elasticities with respect to stocks and world import unit values.

The hypothesis that consumption is a stable function of income and that variations in imports are due to variations in inventory demands was empirically tested. Imports are definitionally equivalent to consumption plus changes in stocks.

Both seasonally adjusted and unadjusted data series were used. The Census Bureau X-11 procedure was used to produce seasonally adjusted quarterly series of relevant variables. In both cases the income variable does not play any significant role in explaining variations in quarterly demands for coffee. However, the elasticity of import demands with respect to inventories turns out to be statistically significant in all cases.

The static model (1) and its alternate form with an income variable have certain limitations since all the response to changes in income or stocks are assumed to be instantaneous. Therefore, a dynamic model was tried that considers both short-run and long-run impacts on endogenous variables. One of the dynamic forms tried was:

$$(2)\quad \begin{aligned} \log I_t = {} & a\lambda + b_1\lambda \log S_t + b_2\lambda \log P_{wt} \\ & + (1-\lambda)\log I_{t-1} + \lambda \log U_t. \end{aligned}$$

For the estimated equation (2), the adjustment coefficient was statistically insignificant and the value of λ turned out to be greater than unity (as estimated, 1−λ was negative). Short-run elasticities with respect to prices and inventories turned out to be −0.32 and 0.28, respectively. The residuals were serially correlated.[4] These results are presented in Table 1.

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* This study was initiated while the author was on the staff of the International Monetary Fund. The views expressed are those of the author and should not be interpreted as those of the International Monetary Fund. The study has been completed at the University of East Anglia, Norwich.

[1] Europe includes all EEC countries, EFTA countries, Spain, Ireland, Finland, Greece, Turkey, and Iceland. The Eastern European countries are excluded.

[2] Lovasy [6, p. 24] has obtained a negative income elasticity for the U. S. This result is not because coffee is an inferior beverage but because the saturation level has been reached. Hughes [5, p. 913] has obtained a negative sign of the income coefficient. This result implied that coffee as an inferior beverage was displaced by one or more beverages such as alcoholic beverages appropriate to higher per capita incomes.

[3] Import unit values are not expressed in terms of index numbers. They are total value of imports divided by total quantity of imports.

[4] Durbin-Watson ratio statistic d is biased upward when there are lagged dependent variables in the equation. Durbin's h-statistic [2, p. 415] cannot be used as $nV(\hat{\beta}) > 1$

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Table 1. Estimated coefficients of U. S. import demands for coffee, quarterly data 1958–1968

Type of Series	Constant	Regressors								$\bar{R}^2$	SEE in percent	DW	DF
		$\log I_{t-1}$	$\log S_t$	$\log P_{wt}$	$\log P_{wt} + \log P_{wt-1}$	$\log S_t + \log S_{t-1}$	D_1^a	D_2^a	D_3^a				
Seasonally Adjusted	3.4170* (5.1690)	0.2314 (1.3710)	0.2818* (3.4670)	−0.3266* (2.1710)						0.3020	3.93	1.227^{c,d}	39
Seasonally Adjusted	3.8630* (4.7040)	−0.0781 (0.4070)			−0.4215* (2.4980)	0.0814 (0.8250)				0.1280^b	4.39	1.684^{c,d}	38
Unadjusted	3.9810* (4.9460)	−0.1412 (0.7300)			−0.2185* (2.4210)	0.0427 (0.8240)	−0.0124 (0.4860)	−0.0431* (1.8340)	−0.0488* (2.2450)	0.2110	4.50	1.6950^{c,d}	35

* Statistically significant at 5 percent level.
[a] D_1, D_2, and D_3 are seasonal dummies.
[b] Relatively low R^2.
[c] Serially correlated residuals; the test is not strictly valid as there are lagged dependent variables.
[d] h-statistic not possible;

$$h = 1 - \tfrac{1}{2}d\sqrt{\frac{n}{1 - n\hat{V}(\mu)}}$$

where $\hat{V}(\mu)$ is the estimate of variance of μ, and μ is the coefficient with respect to lagged dependent variable, and d is the Durbin-Watson ratio statistic.

A dynamic model attempted by Houthakker and Taylor [4] and Houthakker and Magee [3, p. 120] was estimated. A distinction between actual imports and desired imports was made, and actual imports were assumed to adjust to desired imports according to the flow adjustment equation.

$$\frac{\partial \log I_t}{\partial t} = \beta[\log I_t^d - \log I_t] \tag{3}$$

where β is a parameter determining the speed of adjustment. Desired imports were specified as

$$\log I_t^d = \gamma_o + \gamma_1 \log S_t + \gamma_2 \log P_{wt} \tag{4}$$

where S_t and P_{wt} are stocks at-the-end-of the quarter and average quarterly prices, respectively. As shown in [4], these structural equations can be approximated by

$$\begin{aligned} \log I_t = {} & \lambda_o + \lambda_1 \log I_{t-1} \\ & + \lambda_2(\log S_{t-1} + \log S_t) \\ & + \lambda_3(\log P_{wt-1} + \log P_{wt}) + \xi_t \end{aligned} \tag{5}$$

where S_t and P_{wt} appear as moving averages over two periods with short-run elasticities λ_2 and λ_3. Estimates of coefficients γ_1 and γ_2 can be worked out

$$\gamma_1 = \frac{2\lambda_2}{1 - \lambda_1} \quad \text{and} \quad \gamma_2 = \frac{2\lambda_3}{1 - \lambda_1}, \quad \text{and}$$

γ_1 and γ_2 may be interpreted as long-run elasticities. The results presented in Table 1 indicate that short-run price elasticities of import demand are statistically significant while those for stocks are not. The short-run elasticity of demand with respect to price turns out to be −0.22 from the unadjusted series while it is −0.42 from the seasonally adjusted set of data. This latter estimate is inconsistent with the lower annual elasticities, and it is suspected that the adjusted series tends to overestimate the price elasticity. The Census Bureau X-11 procedure applied to all series to remove seasonality might have eliminated the causal contribution of price variable in explaining quarterly variations of import demands. This is seen by comparing the $\bar{R}^2$'s of the adjusted and unadjusted series in Table 1. United States import demand equations from quarterly data indicate the short-run behavior of imports.[5] It is shown that price plays an important role in influencing the imports of coffee by the U. S.

Imports by Other Countries

Coffee imports for a composite group of European countries have increased from 23 percent to 45 percent of world imports during the period 1948–1968. This is probably because coffee drinking has not reached a saturation point in Europe. Improvement in imports exceeded the rate of population growth so that

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where $\hat{V}(\mu)$ is the estimated variance of the coefficient associated with the lagged dependent variable, $\mu = 1 - \lambda$, and n is the number of observations in a given sample.

[5] Some of the variables like stocks and prices may move together in the annual model and may increase the danger of multicollinearity while random factors such as weather will be more prominent in quarterly analysis. Stocks during the fourth quarter will normally be high because this is the harvesting season in most parts of Latin America and Africa. Results of annual import demand functions for the U. S. are not presented here; any interested reader can obtain them from the author.

Table 2. Estimated coefficients of import demand functions for Europe, 1950–1968 annual data

Nature of Dependent Variable	Constant	Regressors			$\bar{R}^2$	*DF*	*SEE* percent	*DW*
		GNP in 1958 Market Prices in Billions of U. S. Dollars	Deflated Prices[a]	Undeflated P_{wt}				
Imports (tons)	19.9400 (0.2820)	3.4170* (24.6680)	−3.8400* (6.1660)		0.9950 (very high)[b]	16	2.260	2.341
Trend eliminated imports	—	1.9840* (5.2890)		−2.5260* (3.5620)	0.6450 (17.3380)[b]	16	17.500[c]	2.825[d]
Trend eliminated imports	—	2.4730* (5.7280)	−2.6220* (3.4470)		0.6350 (16.6260)[b]	16	17.800[c]	2.758[d]

* Statistically significant at 5 percent level.

[a] Deflated by the GNP price deflator only.

[b] *F* value.

[c] Absolute standard error of the estimator.

[d] Test indecisive for negative serial correlation.

on an overall basis per capita consumption moved upward.[6] The principal factors responsible for high growth in imports may be income, declining relative price of coffee, and a general trend effect toward the levels of consumption in the United States. As the trend in GNP[7] at 1958 prices and time-trend was highly correlated, it was decided not to use both explanatory variables. The income and price elasticity of demand computed at mean values for a linear demand function were 1.1580 and −0.1797, respectively. The income elasticity seems to be overestimated. This result is probably due to the general trend effect being confounded with the income effect.

As the European population has increased and consumption of coffee has increased along with income and other effects, the trend effect is very strong in all series. Data on per capita income were not available, and therefore a general time-trend was eliminated from each of the time-series. The linear model yields a short-run marginal propensity to import and a marginal coefficient with respect to deflated prices where GNP price deflator is used for adjusting the coffee prices. All the results are presented in Table 2.

The share of imports excluding the U. S. and European countries accounts for about 10 percent of total world imports. Two of the major importing countries in the Rest of the World group are Canada and Japan. Imports of the Rest of the World may be determined by a general trend effect and prices. Trend measures the effect of rise in population, rise in income, and increased coffee consumption in total. The estimated equation with import prices and trend variable is presented below:

$$
\begin{aligned}
(6)\quad \log I_t &= \underset{(23.7330)}{2.7440^*} - \underset{(5.1300)}{0.3562^*} \log P_{wt} \\
&\quad + \underset{(9.9950)}{0.0123^*} t \\
\bar{R}^2 &= 0.8910 \quad SEE = 7.04\% \\
& \qquad\qquad\quad DW = 0.958.
\end{aligned}
$$

The errors were serially correlated, and so the equation was re-estimated by Cochrane-Orcutt iterative procedure [1] as follows:

$$
\begin{aligned}
(7)\quad \log I_t &= \underset{(3.6078)}{0.3330} - \underset{(0.6599)}{0.0602}\, P_{wt} + \underset{(6.8202)}{0.0222^*} t \\
& \qquad\qquad\qquad\qquad \bar{R}^2 = 0.7251 \\
SEE &= 3.30 \quad S = 0.6939 \quad (S \text{ is autocorrelation coefficient}) \\
DW &= 3.0657 \text{ (negative serial correlation).}
\end{aligned}
$$

A Simultaneous Equations Model and Estimates

The world price was considered to be predetermined. Import demands for the United States, Europe, and Rest of the World were also estimated by a simultaneous equations model in which prices and regional import demand were classified as endogenous variables. A con-

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[6] Sweden continues to maintain its position as the leading coffee consumer in the world with a rate of 28.4 pounds per capita consumption while it is 4.53 pounds for European countries and 14.6 pounds for the U. S.

[7] Data on disposable income for all European countries are not available, and therefore data on gross national product have been used.

Table 3. Two-stage least squares estimates of regional imports for the period 1950–1968

Dependent Variable	Constant	Second Stage Regressors							$\bar{R}^2$/ (F)	SEE percent	DW
		S_t	P_{wt}	RS_t	RP_{wt}	$RGNP_t$	t	$\log P_{wt}$			
I_t^a (U.S.A.)	1293.0000* (10.5040)	1.3280* (4.1250)	−6.0440* (3.3320)						0.7780 (32.5390)	4.0860	1.2950^e
RI_t^b (U.S.A.)				1.2930* (4.1400)	−4.1610 (1.6850)				0.5870 (13.8040)	50.9000^d	1.4300^e
RI_t^b (Europe)					−2.4030* (2.6950)	1.7280* (4.2270)			0.5620 (12.5450)	14.5000^d	2.8290^e
$\log I_t^c$ (Rest of the World)	2.4520* (11.9840)						0.0156* (8.3950)	−0.1824 (1.5610)	0.9410 2.5900	5.4050	

* Significant at 5 percent level.
[a] Correlation between S_t and P_{wt} is −0.57, not too high to affect the results.
[b] Denotes deviations from linear time-trends.
[c] High correlation between P_{wt} and $t (r=-0.82)$.
[d] Not in percentage.
[e] Serially correlated residuals.

densed model[8] estimated for the period 1950–1968 was specified as follows:

(8) World Imports $= WI_t = \sum_{i=1}^{3} I_{it}$

$$= f(S_{it}, P_{wt}, D_{it})$$

$$= a + b_1 \sum S_{it} + b_2 P_{wt} + U_t$$

(9) World Price of Coffee

$$= P_{wt} = f(S_{t-1}, \Delta S_t, D_t)$$

$$= a' + b_1' S_{t-1} + b_2'(EP_t - I_t) + b_3' D_t + V_t$$

(10) Changes in World Stocks

$= \Delta S_t = WEP_t - WI_t =$ World Exportable Production less World Imports.

Equation (8) is the import demands by region equation and is determined by level of stocks in importing countries or income, world price of coffee, and a labor strike in an importing country. World price of coffee (9) is determined by level of stocks at the beginning of the year, excess supply or demand at the world level, and any other unusual factor (frost, drought or quota) in an exporting country. Equation (10) is a definitional relationship referring to excess supply/demand during the current year; this relationship is substituted in the structural equation (9). Regional imports were estimated by two-stage-least-squares as these equations are overidentified.

Regional import demand equations were estimated by two-stage-least-squares, and these estimates are presented in Table 3. Multicollinearity among explanatory variables and serial correlation of residuals were the principal problems which were tackled in the estimation of U. S., European, and Rest of the World import demands.

The predictive efficiency of estimated import demands were examined for the sample period 1950–1968, and this was quite high. Structural coefficients with respect to income, prices, and stocks derived from regional import demand functions reflect the structure of import demands by regions. The regional import equations were used to predict regional and total import demands for the period 1969, 1970, and 1971. The predicted regional and total import demands are presented in Table 4, and they are compared with the actual world imports for the period 1969, 1970, and 1971.

Table 4. Estimated and actual imports[a] by regions, 1969–1971

Year	U.S.A.	Europe	Rest of the World	Total
		1000 tons		
1969	1423 (1214)[b]	1577 (1630)	301 (313)	3301 (3197)
1970	1357 (1184)	1614 (1639)	296 (356)	3267 (3181)
1971	1382 (1299)	1645[c] (1617)	327 (346)	3354 (3262)

[a] Actual prices in 1969 and 1970 are assumed to be known, or alternatively, it is assumed that prices are forecast without any error for the years 1969 and 1970.
[b] Figures in parentheses are actual imports.
[c] Based on predicted GNP.

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[8] A complete model consisting of nine equations is not presented here. A detailed description of the model is available in [7].

References

[1] Cochrane, D., and G. H. Orcutt, "Application of Least Squares Regressions to Relationships Containing Autocorrelated Error Terms," *J. Am. Stat. Assoc.* 44:32–61, March 1949.

[2] Durbin, J., "Testing for Serial Correlation in Least Squares Regression When Some of the Regressors are Lagged Dependent Variables," *Econometrica* 38:410–422, May 1970.

[3] Houthakker, H. S., and S. Magee, "Income and Price Elasticities in World Trade," *Rev. Econ. and Stat.* 51:111–125, May 1969.

[4] Houthakker, H. S., and L. D. Taylor, *Consumer Demand in the United States, 1929–1970*, Cambridge, Harvard University Press, 1966.

[5] Hughes, J. J., "Note on U. S. Demand for Coffee," *Am. J. Agr. Econ.* 51:912–914, Nov. 1969.

[6] Lovasy, G., "Development of U. S. Coffee Consumption: Analysis and Forecast," Econ. Dept. Working Paper 9, International Bank for Reconstruction and Development, Nov. 1967.

[7] Parikh, A., "A Model of World Coffee Trade," mimeographed paper, Nov. 1970.

Table 4. Size distributions of soybean processing firms, actual and theoretical lognormal, selected years

Year beginning October 1	Size Category (percent of industry capacity)				
	I(0>75)	II(75>90)	III(90>95)	IV(95–100)	Total
			Number of Firms		
1946					
Actual	17	26	17	29	89
Theoretical	28.7	21.0	14.6	24.7	89
1953					
Actual	16	20	17	32	85
Theoretical	23.3	20.2	11.2	30.3	85
1957*					
Actual	13	14	11	30	68
Theoretical	16.5	15.1	9.6	26.7	68
1961*					
Actual	11	15	10	29	65
Theoretical	15.0	14.2	9.3	26.5	65
1965*					
Actual	8	9	7	25	49
Theoretical	8.9	9.8	7.0	23.3	49
1971*					
Actual	11	8	6	18	43
Theoretical	8.3	8.8	6.2	19.7	43

* Using the Chi square test, the theoretical distribution did not differ significantly from the actual in these years.

growth rates are independent of firm size. If so, then as firms expand, they might be expected to grow according to the "law of proportionate effect." Such growth over time would lead to generation of lognormal size distributions of firms and to increasing relative dispersion of sizes of firms [3].

To test for lognormality, theoretical lognormal distributions of firms were compared with distributions actually observed.[3] Theoretical distributions were derived from areas under the normal curve using the mean and variance of logarithms of firm sizes in each of the observation years (Table 4). The comparisons showed generally that actual size distributions of firms in recent years were consistent with the lognormal hypothesis.

Of particular interest in market structure analysis are tendencies among the largest firms. To focus more directly on the upper end of the size distribution, the share of industry capacity held by the largest four firms was compared with theoretical lognormal four firm concentration ratios derived from areas under the normal curve and with ratios simulated using the mean and variance of logarithms of actual firm sizes (Table 5).

The simulated average ratios were consistently lower than the theoretical ratios derived from areas under the normal curve. This arose because the range of sample values drawn from a normal distribution tends to be narrower for small samples than for large samples. Since the number of firms in the industry was relatively small, the probability of obtaining a high random value in any particular simulated sample was quite low.[4]

Owing to this characteristic, the comparison

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[3] Silberman [8] examined 90 industries for 1947 and 1958 and found that about half could be described as lognormal. A smaller proportion of the industries with relatively few firms, i.e., less than 100, were found to be lognormal than the portion of industries with larger numbers of firms.

[4] Snedecor [10, pp. 97–99] has shown that as more items are drawn from a normal population, there is an increasing likelihood of including some of the unusual extremes which are in the population. Thus range and standard deviation tend to increase with sample size, but range goes faster, and the ratio of the range to the standard deviation rises.

To determine whether the simulated average ratio would approach the ratio derived from the area under the normal curve as sample size was increased, the number of firms in the sample was multiplied by 100, samples were drawn, and concentration ratios were computed for the top 400 firms. For example, for 1971 a sample size of 4300 was used instead of 43, and the ratio was based on the top 400 rather than the top four. This procedure was also followed for the number of firms in 1961 and 1965. In each of these three years, the simulated ratios were nearly identical with the ratios derived from the areas under the normal curve.

Table 5. Four firm concentration ratios in the U. S. soybean processing industry, actual and theoretical, selected years

Year beginning October 1	Four Firm Concentration Ratio			
	Actual	Theoretical Lognormal: Derived from area under normal curve[a]	Theoretical Lognormal: Simulated average[b]	Standard deviation of simulated concentration ratios[b]
	Percent of Industry Capacity			
1946	43.8	28.9*	27.2*	5.6
1953	35.3	34.6	32.4	7.0
1957	38.6	42.2	39.4	8.6
1961	46.8	44.8	41.1	9.0
1965	51.9	57.6	52.3	10.6
1971	51.7	58.7	53.6	10.6

[a] The procedure was as outlined by Silberman [8].

[b] The simulated four firm concentration ratios were obtained by using random normal deviates generated from a computer program of random numbers. Each deviate (U_i) was then converted to an element of a sample of size N, where N was the actual number of firms in that particular year, using the transformation $X_i = e^{M+VU_i}$. Repeating this N times gave a sample of size N from a lognormal population with parameters M and V^2, where M and V^2 were the mean and variance of logarithms of firm size. The top four simulated firm sizes were then divided by the simulated total industry size. The entire process was repeated 1,000 times. The mean and variance of the 1,000 simulated four firm concentration ratios were then computed.

* Significantly different from the actual at the 1 percent probability level based on t test using standard deviation of 1000 simulated concentration ratios for each year.

of actual ratios with the simulated average would be more realistic than the comparison of actual ratios with the theoretical ratios derived from areas under the normal curve. Nevertheless, the actual four firm concentration ratio fell within a range that indicated no significant difference, except for 1946, from either the simulated or derived ratio. Thus the results for the upper ends of the distributions were generally consistent with the findings of lognormality with respect to the entire distributions.[5]

Table 6. Projected number of soybean processing firms in the U. S. by around 1980 by size groups, from three base periods

Size Category (percent of capacity)	Projection Base Period: 1953–54 to 1961–62	1961–62 to 1971–72	1965–66 to 1971–72
	Projected number of firms by[a]		
	1979–80	*1981–82*	*1977–78*
I (0>75)	6.7	10.6	12.9
II (75>90)	7.8	5.3	7.6
III (90>95)	7.2	4.4	5.0
IV (95—100)	22.5	13.8	13.6
TOTAL	44.2	34.1	39.1

[a] Carried to one decimal place as given by mathematical projections. In reality only whole numbers are logical.

However, the actual ratios were below the simulated average ratios in 1957, 1965, and 1971 and above in other years. If trends of the 1960's continue, the four firm concentration ratio may at some time in the future be significantly lower than the ratio indicated by the lognormal hypothesis.

Future Projections of Size Distributions from Alternative Past Periods

A Markov Chain process [1, 2] was employed to bring out more clearly the potential future implications of past developments in the size distribution of firms from selected recent periods (Table 6). The principal tendency was the projected increase in the number of firms required to account for three-fourths of industry capacity by around 1980 from the later base periods. This points toward decreasing concentration at the upper end of the size distribution, as was indicated in the tests for lognormality in the preceding section. But at the same time, each projection indicated fewer small firms and a further decline in the total number of firms. Of course, these projections are not actual forecasts but indications of tendencies. Their relevance in forecasting will depend upon the extent to which changing or new factors might modify size distribution developments which occurred during the projection base periods.

Summary and Implications

Growth of the soybean processing industry between 1946 and 1971 was accompanied by substantial change in the number and relative sizes of firms. The number of firms declined

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[5] The procedure which derives the theoretical ratio from areas under the normal curve has also been criticized because the sampling error of the actual ratio can be experimentally obtained only by performing repeated sampling experiments, in which the assumption is made that the sampling distribution of the actual ratio is normal [6, 9]. Thus an alternative two-tailed distribution-free test of significance was performed. The samples simulated for Table 5 were used.

The test at the 5 percent level was of the following form:

$$C = (L + 1)\frac{\alpha}{2}$$

$$= (1000 + 1)\frac{.05}{2}$$

$$C = 25.025.$$

The null hypothesis that the actual four firm ratio is from a lognormal distribution is rejected if there are fewer than 25 simulated ratios which are either greater or less than the actual ratio. Only for the year beginning October 1, 1946 was the null hypothesis rejected, which is consistent with the conclusions reached above.

more rapidly than the number of plants. Several firms and plants were acquired by other processors. Plants operated by the largest four firms rose from 14 to 37, while those operated by all other firms declined from 104 to 50.

The share of industry capacity operated by the largest four firms declined between 1946 and 1953, gradually rose through 1965, then remained approximately stable through 1971. Disparity among firm sizes correspondingly rose as concentration increased, and size dispersion decreased slightly between 1965 and 1971.

The hypothesis of lognormal size distributions of firms could not be rejected for any observed year since 1953. Upper ends of the size distributions were consistent with the lognormal hypothesis for all years since 1946. Markov Chain projections indicated that if past trends continue, fewer small than large firms will survive, and the total number of firms will likely decline further. At the same time, if developments during the late 1960's prevail, some decrease in industry concentration might be anticipated.

This industry clearly has gone through a remarkable transformation in the past quarter century. An important question is whether approximate stability in shares held by leading firms in recent years is likely to endure. A related question is how much further reduction may occur in the total number of firms. This will depend importantly on whether intermediate size firms, including several which operate single plants, will be numerous and vigorous enough to compete effectively and the extent to which they may be acquired by other firms. Answers to questions of this type will be of vital concern both to firms in the industry and from the standpoint of public policy.

References

[1] FARRIS, PAUL L., "The Changing Profile of Indiana Dairy Plants," Purdue Univ. Agr. Exp. Sta. Res. Progress Rep. 318, Sept. 1967.

[2] ———, AND DANIEL I. PADBERG, "Measures of Market Structure Change in the Florida Fresh Citrus Packing Industry," *Agr. Econ. Res.* 16:93–102, Oct. 1964.

[3] HART, P. E., "The Size and Growth of Firms," *Economica*, New Series, 29:29–39, Feb. 1962.

[4] KROMER, GEORGE W., "U. S. Soybean Processing Capacity Expanding," *Fats and Oils Situation*, USDA ERS FOS-255, Nov. 1970.

[5] NAKAMURA, HIROSHI, AND THOMAS A. HIERONYMUS, "Structure of the Soybean Processing Industry," Ill. Agr. Exp. Sta. Bull. 706, Feb. 1965.

[6] QUANDT, RICHARD E., "Lognormality and Concentration: Comment," *Am. Econ. Rev.* 58:1367–1370, Dec. 1968.

[7] REILLY, WILLIAM R., "A Market Structure Analysis of the Soybean Processing Industry," unpublished Ph.D. thesis, Purdue University, 1965.

[8] SILBERMAN, I. H., "On Lognormality as a Summary Measure of Concentration," *Am. Econ. Rev.* 57:807–831, Sept. 1967.

[9] ———, "Lognormality and Concentration: Reply," *Am. Econ. Rev.* 58:1370–1371, Dec. 1968.

[10] SNEDECOR, GEORGE W., *Statistical Methods*, 4th ed., Ames, The Iowa State University Press, 1948.

[11] U. S. Department of Commerce, Bureau of the Census, 1967 Census of Manufactures, *Concentration Ratios in Manufacturing*, Part I, Special Report, Washington, August, 1970.

[12] VELDE, PAUL DWIGHT, "The Impact of Transit and Nontransit Transportation Rate Structures on the Soybean Processing Industry," unpublished Ph.D. thesis, Purdue University, 1970.

A Note on the Stability of Firm Size Distribution Functions for Western Cattle Ranches*

C. T. K. Ching

Negative exponential functions adequately describe the size distribution of western cattle ranches. Further, these functions were found to be sufficiently stable over time to be used in projecting future size distributions of firms. As such, these exponential functions provide an attractive alternative to Markov type projections.

Economists are frequently interested in projecting the firm size distribution of a particular industry in their investigations of structure. A useful way for making such projections has been the probabilistic method due to Markov.[1] A limitation of the Markov approach is that it requires detailed information on changes in firm size in order to derive transitional probabilities. Thus, in those instances where the research economist lacks the resources to collect such data, Markov type estimates of size distributions are difficult to obtain.[2]

Boxley [2] described an alternative to the Markov method through which firm size distributions could be estimated when detailed information on firm size changes were not readily available.[3] Boxley suggested that the size distribution of firms in an industry can be described empirically by a function of the form:

$$Y = Ae^{-BX} \tag{1}$$

where:

Y = percentage (of firms) remaining above certain size limits,
X = relative firm size (lower limit of size category divided by average firm size),
e = irrational number equal to 2.71828.

The rationale for such a procedure is based on the nonrandom nature of past fragmentation and consolidation of farms. More specifically, "any change in the number of farms of a given size requires either a change in the land base or offsetting changes in other size categories. If changes occur over a constant land base, the possible farm size combinations are physically constrained by that land base and by the fact that the maximum number of farm units that can be created of a given size is inversely related to that size" [2, p. 88].

Boxley [2] fitted these functions using census data on farm size measured in acres for each of the coterminous states in the United States. His results generally indicated that in many states, the negative exponential function fits very closely the size distribution of farms. However, much more important for the purpose of estimating future size distributions, Boxley noted that these functions are relatively stable over time. Thus, to project the size distribution of firms for some future time, all one need do is estimate average firm size for the time period in question and transform the argument of the distribution function.

The objective of this paper is to investigate the appropriateness of the negative exponential function, as an alternative to the Markov approach, in describing the size distribution of western cattle ranches. Further, the stability of these functions will be tested statistically. Fulfillment of both objectives should provide insights into the usefulness of negative exponential functions to predict future firm size distributions.

Procedure

The negative exponential function was fitted to the size distribution of cattle firms in each of the 11 western states. Census data was used in fitting the functions. For the purpose of this study cattle firms include both "livestock farms" and "livestock ranches" as defined in the Census of Agriculture [4]. It was thought appropriate to combine these two categories since a firm that is primarily a range cattle operation might be classed as a livestock farm if its major private land holdings were crop-

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[1] For example, see Adelman [1].

[2] It should be noted, however, that techniques are available for estimating transitional probabilities from aggregate time series data. See [6, 5].

[3] Much of the work on fitting exponential size distributions originated with Dovring [4].

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land but depended upon Federal grazing for a major portion of feed requirements.

Firm size in this paper is measured in number of cows rather than in number of acres of land controlled by the livestock firm. Herd size is a traditional measure of livestock firm size because of the wide variation in productivity of western rangelands. In aggregate, however, it is reasonable to expect that there is a fixed, or at least stable, relationship between number of acres of grazing land and number of cattle that can be supported. Accordingly, measurement of firm size in terms of number of cows does not appear to be a serious departure from Boxley's firm size-land base relationship noted above.

The estimating procedure followed differs

Table 1. Estimated coefficients and test statistics for size distribution functions, 11 western states

State	Year	Intercept	Slope	Std. Error	R^2	"Chow" F[a] Statistic
Montana	1959	101.279	−1.160	.029	.998	(2.915)
	1964	100.983	−1.120	.012	.999	
	1969	100.865	−1.136	.025	.999	
	1959–64	100.863	−1.133	.019	.999	
Idaho	1959	101.992	−1.139	.098	.958	(1.307)
	1964	101.290	−1.004	.078	.965	
	1969	101.234	−1.031	.074	.970	
	1959–64	101.254	−1.047	.046	.960	
Wyoming	1959	101.204	−1.297	.058	.988	(3.219)
	1964	100.861	−1.174	.046	.991	
	1969	100.805	−1.197	.031	.996	
	1959–64	100.814	−1.210	.026	.990	
Colorado	1959	101.870	−1.180	.080	.973	(3.245)
	1964	101.274	−1.021	.060	.980	
	1969	101.149	−1.050	.046	.989	
	1959–64	101.168	−1.068	.036	.975	
New Mexico	1959	101.400	−1.376	.094	.972	(1.821)
	1964	101.010	−1.217	.081	.974	
	1969	100.927	−1.284	.059	.987	
	1959–64	100.920	−1.274	.043	.975	
Arizona	1959	100.892	−1.479	.099	.974	(3.509)
	1964	100.622	−1.238	.115	.951	
	1969	100.664	−1.212	.084	.971	
	1959–64	100.639	−1.271	.060	.953	
Utah	1959	102.163	−1.138	.063	.982	(2.501)
	1964	101.457	− .995	.057	.981	
	1969	101.318	−1.023	.066	.976	
	1959–64	101.337	−1.039	.036	.974	
Nevada	1959	100.686	−1.710	.141	.961	(.897)
	1964	100.485	−1.561	.086	.982	
	1969	100.535	−1.637	.083	.985	
	1959–64	100.505	−1.624	.052	.978	
Washington	1959	102.855	−1.093	.113	.939	(2.925)
	1964	101.770	− .816	.136	.859	
	1969	101.673	− .901	.116	.910	
	1959–64	101.683	− .906	.075	.871	
Oregon	1959	101.931	−1.395	.187	.902	(1.417)
	1964	101.234	−1.121	.201	.839	
	1969	101.174	−1.158	.160	.897	
	1959–64	101.214	−1.197	.103	.860	
California	1959	101.695	−1.396	.147	.938	(1.670)
	1964	101.157	−1.133	.162	.890	
	1969	101.072	−1.201	.135	.929	
	1959–64	101.082	−1.213	.085	.902	

[a] This statistic is significant at the 5 percent level of confidence for the values greater than F (2, 18) = 3.55.

slightly from that reported by Boxley. Since the smallest size class reported in the Census was one cow, ordinary least squares procedures were modified by constraining the estimated function to pass through the point corresponding to 100 percent and relative size defined for the lower limit of the smallest size class.[4] Restricting least squares procedures in this manner guarantees that the estimated size distribution function reflects the logical result that 100 percent of the firms had at least one cow.

Distribution functions were fitted using data from the Census of Agriculture for the years 1959, 1964, and 1969. Thus three equations were derived for each state. To test for stability of these functions over time, the equations for each state were tested for significant differences using the method developed by Chow [3]. The hypothesis that "the data used in estimating the parameters of each equation belong to the same regression equation" is tested.

Statistical Results

Least squares estimates of the parameters in Equation 1 and their related test statistics are presented in Table 1. Without exception, the slope coefficients for the equations for each state are significantly different from zero at the 1 percent level of confidence. Further, the coefficients of determination (R^2) are all high, ranging from about 0.84 to 0.99. These coefficients indicate that generally over 90 percent of the variation in decumulative firm size percentage was explained by variations in relative firm size. Note that all states except Washington, Oregon, and California exhibit coefficients of determination greater than 0.95. For the Pacific Coast states, the coefficients of determination fell below 0.90 in several instances. While there is nothing sacred about a coefficient of determination of 0.90, these results suggest that, in a relative sense, the negative exponential functions are less appropriate for these states than for the other western states. Resources devoted to cattle ranching in the Pacific Coast states may not be as stable as those in the other western states. That is, resources released from defunct cattle ranches in the coastal states may not be absorbed by viable participants in the ranching industry.

The Chow F statistics (Table 1) indicate that for each state the data for 1959, 1964, and 1969 belong to the same regression equation. In other words, the estimated parameters of the size distribution functions for each state are not statistically different for the three census years considered. Alternatively, these results suggest that for each state, the percentage of firms above average firm size are equal in each of the three census years considered. Of course, average firm sizes have changed over time. For example, in Montana, the average firm size was 91 cows, 114 cows, and 132 cows, in 1959, 1964, and 1969, respectively. For each of these years approximately 32 percent of the firms in Montana were above this size class. More specifically, estimates of the percent of firms above average firm size (relative size equal to one) for the 1959, 1964, and 1969 functions were 31.7, 32.9, and 32.3, respectively. Using the combined data equation, 32.6 percent of the firms were above average firm size.

The statistical results presented suggest two major findings. First, the negative exponential functional form does fit the size distribution data for western livestock firms quite well. Second, the functions (for each state) over the three time periods studied are stable. The stability of these functions suggests their appropriateness in making estimates of future firm size distributions.

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[4] In the equation $Y=Ae^{BX}\epsilon$, where ϵ is the disturbance term, the parameters A and B are derived by minimizing $\Sigma\epsilon^2$ subject to the condition that $A=100/e^{BX}$ where X_1 is the "relative size" corresponding to the lower limit of the smallest size class.

References

[1] Adelman, I. G., "A Stochastic Analysis of the Size Distribution of Firms," *J. Am. Stat. Assoc.* 53:893–904, Dec. 1958.

[2] Boxley, Robert F., "Farm Size Distribution of Farm Numbers," *Agr. Econ. Res.* 23:87–94, Oct. 1971.

[3] Chow, Gregory C., "Tests of Equality Between Sets of Coefficients Between Two Linear Regressions," *Econometrica* 28:591–605, July 1960.

[4] Dovring, Folke, *Farm Size Data: Frequency Distribution, Interpolation and Projection*, Illinois Agr. Exp. Sta. Res. Rep. AERR-50, May 1962.

[5] Krenz, Ronald D., "Projection of Farm Numbers for North Dakota with Markov Chains," *Agr. Econ. Res.* 16:77–83, July 1964.

[6] Lee, T. C., G. G. Judge, and T. Takayama, "On Estimating the Transition Probabilities of a Markov Process," *J. Econ. Farm.* 47:742–762, Aug. 1965.

[7] U. S. Department of Commerce, Bureau of the Census, *U. S. Census of Agricultural 1959 Nevada Counties*, p. XXIV.

Increasing Response Rates in Mailed Questionnaires*

R. C. Buse

Described is a procedure using a personal letter to a questionnaire recipient to capture attention, develop rapport, and capitalize on this plus persistence to achieve a high response rate. Also examined is the question of bias associated with nonrespondents. The evidence presented supports the practice of pursuing high response rates.

Low cost per unit and easier access to certain groups or individuals are advantages that make the mail questionnaire an attractive research tool.[1] In practice, however, poor response rates frequently affect the mail questionnaire's data-generating ability. Biased survey results occur when nonrespondents differ from respondents.[2] Other factors which affect questionnaire reliability such as content and design quality are covered extensively in the literature. This note, however, is concerned primarily with the response rate aspect of questionnaire efficiency.

A large body of literature exists on effective techniques for increasing mail questionnaire response rates.[3] Major assumptions of this literature are: (a) a questionnaire, no matter what its form or type, is an imposition on the respondent who must volunteer his time and energy; (b) the impersonal nature of the mail contrasted to face-to-face interviews makes it easy to refuse; and (c) mail questionnaires have stiff competition for the addressee's attention because he is currently exposed to many such mailings. These factors help account for the commonly encountered 50 per cent response rate.

Two approaches exist for improving response rate. One, the "sledgehammer" approach, relies on successive waves of questionnaires with follow-up reminders and pleas. A second, more imaginative approach attempts to identify possible reasons for nonresponse. It involves anticipating resistance and increasing respondents' personal involvement.[4] A combination of the two approaches, individually tailored to the project, is complementary and yields high payoffs.

The Wisconsin Incorporated Farm Study

A mail questionnaire was used in this study to provide some descriptive statistics of incorporated farms in Wisconsin and to serve as a basis for sampling in later stages of a longer run project. To provide an adequate sampling frame for later stages, response rates had to be as close to 100 percent as possible—a major challenge for the mail questionnaire. A small budget plus time pressure made a mail survey

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[*] A more detailed explanation of methodology used in this study is available in Research Report R2409, College of Agricultural and Life Sciences, University of Wisconsin, Madison, Wisconsin, 53706. The research on which this paper is based was conducted as a joint project between the Economic Research Service, USDA, and the Wisconsin Agricultural Experiment Station, Madison, Wisconsin. The author wishes to thank Daniel Bromley, Aaron C. Johnson, Jr., and Peter Helmberger of the University of Wisconsin, and John T. Scott, Jr., and Mathew Hauck of the University of Illinois, for their comments on an earlier draft of this paper.

[1] For a detailed discussion of the relative merits and deficiencies of the mail questionnaire, see [10, pp. 209–213; 12, pp. 170ff.; and 24, pp. 236–243].

[2] The literature is not in agreement on this point. A number of studies have reported differences between respondents and nonrespondents to mail questionnaires while others have found no significant difference. Ferber found that later respondents are "almost non-respondents" and suggested a method of eliminating this [11], while Eckland [9], Mayer and Pratt [18] and McDough [19] present evidence to the contrary. In contrast, Wallace [28] takes the middle ground arguing that the degree of bias due to nonresponse is dependent upon the objectives and intended population of the survey. Robins [22] presents the parallel cost benefit arguments for the case of a face-to-face interview. For some of the many other references on the subject, see Wales and Ferber [27, p. 44–48].

[3] Notable among these studies are: Mason [17] who tested the effect of length of questionnaire and the anonymity of the respondent on response rates. Brodt [5] suggested the use of postcards to preserve anonymity and still permit follow-up. Boek [4] and Nichols [20] provided some further tests and refinements to the postcard technique. Donald [8], Ferness [10], Clausen [6], Plug [21], and Roeher [23] contributed to the concept of personalization as an effective technique for increasing efficiency. Gullahorn [16] suggested the use of special delivery follow-up, and Backrock [1] combined a number of the above techniques to increase his response rate substantially. For a more comprehensive list, see [22].

[4] Clausen and Ford [6] show that high levels of interest and involvement are more likely to be characteristic of early respondents. Ferness [13] and McDough [19] use this knowledge to increase their response rates. Frankel [14] also discusses this question.

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the most practical method of obtaining the required information—provided its overall efficiency could be improved.

The assumption that a properly conceived letter provided easier access to the chief executive of a corporation than a personal appearance was another consideration favoring the mail method. His tacit approval would automatically improve response rates since it would increase the cooperativeness of whomever he requested to complete the questionnaire. The problem was to make sure he personally received the request, to convince him of its merits, and to induce him to cooperate. After a careful reading of the literature, the following procedure was utilized to overcome the obstacles.[5]

The Procedure

Stage 1, advance mailing

An advanced, first class mailing was made to 880 corporation presidents. It contained two letters and a self-addressed, return postcard. The first letter, signed by the Dean of the College of Agricultural and Life Sciences, was designed to lend authority (and thereby justification and an aura of officiality) to the subsequent proposed questionnaire. It stated the reasons for the study and explained it was under the auspices of the University and the College. It also stressed the importance of the individual's participation in the study and introduced the researchers by name.

The second letter, signed by the researchers named in the Dean's letter, (a) elaborated on the purpose and objectives of the study; (b) indicated the approximate date the respondent could expect to receive the questionnaire (two weeks later); (c) stressed the need for the individual's cooperation and the confidential nature of the response; and (d) requested the individual to return the enclosed, self-addressed, stamped postcard if his corporation would cooperate. The postcard asked for a commitment to cooperate and for the name and address of the corporate officer who would fill out the questionnaire.

The guiding philosophy at this stage was to simulate as closely as possible a person-to-person setting for the letters. The individual's addresses and greetings were individually typed on each letter and envelope. The body of the letter was fast-copied on the appropriate university letterhead with the full signature of the authors. The type and the ribbons used in the typewriters were carefully matched, making the heading and greeting almost indistinguishable from the mass-produced body of the letter. To further de-emphasize the impersonal nature of the letter, individual postage stamps were used in lieu of a postage meter.[6]

Attention was given to such details as coordinating mailings to minimize conflicts with holiday mail or, after the first of the year, with income tax mail. In special cases, handwritten notes added further personalism at this and later stages.

Stage 2, the questionnaire

The questionnaire was sent *special delivery* to all respondents who had been alerted by the advance letter or who had been designated by the corporation president in the return postcard. Special delivery reinforced the personal nature of the correspondence and demonstrated the importance the researchers attached to the study and each response. The individually addressed and stamped envelopes included:

1. A second fast-copied cover letter cosigned by the researchers and using University letterhead. It also had the appearance of a personal letter. It repeated the request for cooperation, the great need for the information, its usefulness (a law was under consideration in the state assembly), the pledge of non-disclosure, and the offer of a copy of the final report.
2. A self-addressed and stamped, first class envelope for the return of the completed questionnaire.
3. A six-page questionnaire. The questionnaire contained a title page provided by the computer which asked the respondent to respond only in terms of the particular corporation named on that page.[7] This

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[5] Aside from the standard references [2, 15, 24, 29], the development of the procedure reported herein is a synthesis and a duplication of the ideas and methods described in [1, 16, 18, 23].

[6] This is based upon the observations of the author in watching people sorting their mail. Usually all letters with stamps and individually typed addresses are laid aside to be attended to first, and all material identified as metered mail and those envelopes with address labels are left until later.

[7] In a number of cases, one individual was the chief executive of several corporations. These were individually handled in order to minimize the possible antagonisms of individuals receiving more than one questionnaire or letter. A personal, handwritten note was attached to each to further overcome the additional resistance such respondents might develop by receiving more than one questionnaire.

title page assured the respondent that it was attached to the questionnaire strictly for record-keeping purposes and that it would be removed upon receipt of the questionnaire. The questionnaire itself contained no means of identifying the respondent or his firm.[8] The lower half of the page was perforated and was to be filled out with a name and address if the respondent wished to have a copy of the final report.[9] This offer further reinforced legitimization of the request for information and emphasized one of the benefits of participating, i.e., a report on corporation farms.

Stage 3, first follow-up

A follow-up first class letter was sent to all corporations not responding by the 14th day after the initial mailing. It followed the same personalistic format as earlier letters. It expressed a special thank you to those who had already responded (to allow for crossing in the mails) and a polite personal request for those who had not filled out the questionnaire to set aside a few minutes at that time to do so.

Stage 4, second follow-up

On the 25th day, a second follow-up, *special delivery package, return receipt requested,* was sent to all outstanding corporations. Equal attention was given to all the personalizing techniques used in the previous stages. The package included another copy of the questionnaire with its cover page and a pre-addressed, stamped return envelope. A cover letter reiterated the need for the firm's information for purposes of completeness and set a deadline of seven days hence for completing the return.

Stage 5, telephone follow-up

Finally, after 55 days, instead of following up with another letter, all remaining nonrespondents were contacted by telephone. They were reminded of the questionnaires, the importance of the report for corporation farms, and the need for complete information. Part of the strategy at this stage was to make the respondent feel he was delaying the project. Interviewers tried to determine if the interviewee was likely to return a questionnaire. If not, the interviewers attempted to complete the questionnaire over the phone.

Table 1. Distribution of 880 Wisconsin corporations according to their response to a mailed questionnaire, 1970

Type of Response	Number	Percent
Responded: Classified as Agricultural Corporation*	558	63.4
Responded: Classified as Nonagricultural Corporations**	183	20.7
Responded: Dissolved, Merged, or Out of Business	56	6.4
No Response	83	9.5
TOTAL	880	100.0

* The respondents were classified as agricultural corporations if they recorded income from the production and/or sale of agricultural products.

** Includes 24 real estate agencies with small income from land rental.

The "last ditch" telephone calls were based on the work of Sudman [25], who indicates that telephone interviewing, if properly conducted, can be as effective as face-to-face interviews. It also provided an additional low cost opportunity to test validity effects of differences between non-, late, and early respondents.

Results

The response rate

The procedures were clearly successful. The response rate was 91 percent, a significant improvement over the 50 percent return rate normally expected with mail questionnaires (Table 1). Only 83 out of 880 (9 percent) were classified nonrespondents. Interestingly, 183 corporations without agricultural income and 56 corporations which no longer existed responded. Many of these 239 firms took the time and effort to write a letter stating that they would like to cooperate but explained why they felt the firm should not be included in the survey. This unusual cooperation and interest offers further evidence that the procedures appear to be responsible for the increased response rates.

Figure 1 illustrates daily and weekly returns of the 845 questionnaires mailed on January 9, 1970. A notable jump in the rate of returns occurred after both the first and the second follow-ups (Stages 3 and 4).

Impact of the first follow-up was short run.

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[8] This was to reinforce the statements of anonymity in the cover letter.

[9] It is difficult to ascertain exactly how much or if this increased response except to point out that 80 percent of those responding did request a report. Furthermore, no one who did not return the questionnaire filled out the tear-off requesting a copy of the report.

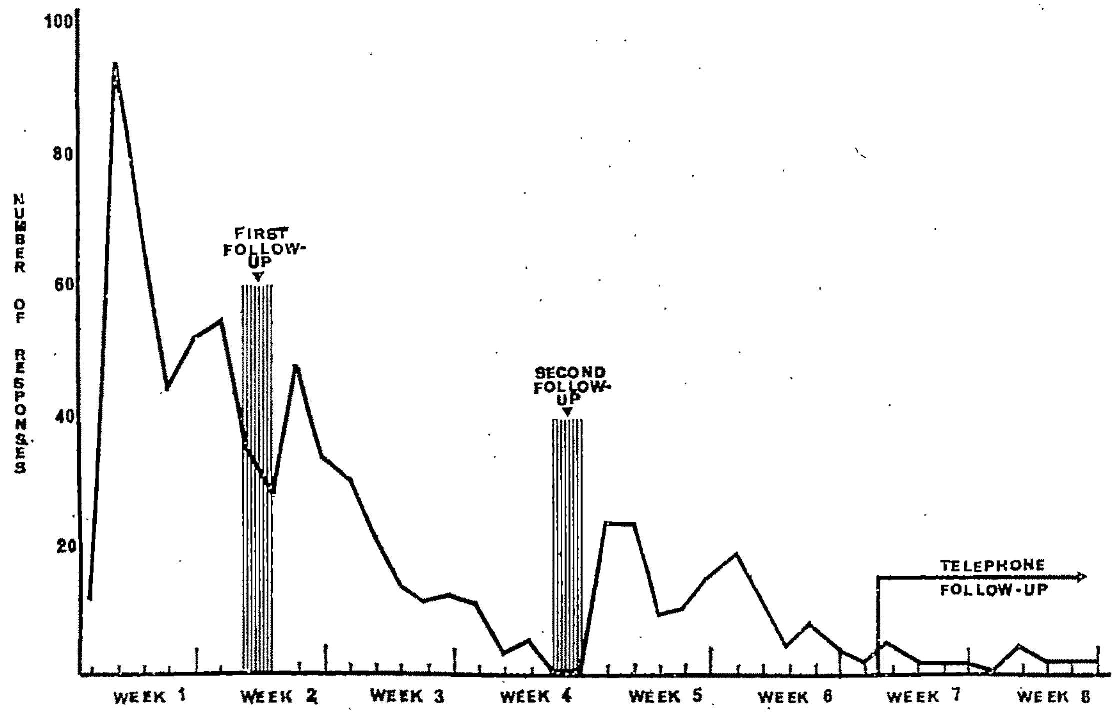

Figure 1. **Frequency distribution of mailed questionaires returned by agricultural corporations by weeks, January to March 1970**

A short spurt occurred in the return rate, but it dropped to the original level within a week. The second follow-up was better timed. Its influence on questionnaire return was still visible one and a half weeks later. The telephone follow-up (Stage 5) contributed to the overall high rate of response by stimulating a continuous trickle of returns into the ninth week.

Respondent characteristics

Table 2 contains the average of selected variables by response waves. Additional characteristics could have been included, but the conclusions would not have changed. The first wave includes those responding to the original mailing and first follow-up letter (Stages 2 and 3); the second, those responding to the second mailing (Stage 4); and the third, those responding to the telephone follow-up (Stage 5).

Substantial differences existed between the groups in each stage. Variances for each cell were significantly different by *Bartlett's Test for Homogeneity of Variance* [3]. Generally, the first wave had the largest variance in the income variables and the second group in those characteristics associated with the farm operation, such as acres, average number of livestock, etc. The third group generally was a more homogeneous group and tended to be smaller in size but selling higher valued specialty products. The heteroskedastic nature of the three waves makes a comparison of averages meaningless. Nevertheless, it is clear that the agricultural aspects of the second and third waves are different from the first wave.

Respondents were also classified on the basis of the corporation's most important source of income. No statistically significant difference existed between the three waves in the dis-

Table 2. **Averages of selected corporation characteristics by response wave, corporations with agricultural income, Wisconsin, 1970***

Characteristics	Respondents in		
	First Wave (Stages 2 and 3)	Second Wave (Stage 4)	Third Wave (Stage 5)
	—Average per Respondent—		
1968 Gross Income	826,636	147,480	400,380
1968 Net Income	70,025	−889	75,097
1968 Net Agricultural Income	6,215	−3,536	606
Number of Individuals Owning Stock	4.1	5.5	3.5
Acres Owned	585	861	312
Acres Operated	517	995	219

* The first wave is defined as those responding to the original mailing and first follow-up; the second wave to those responding to the second mailing; and the third wave to those responding to the telephone follow-up.

Table 3. Calculation of cost per questionnaire returned by original mailing and follow-ups, Wisconsin corporation farm survey, 1970

Cost Explanation	Pre-Questionnaire Mailing (Stage 1)	Questionnaire Mailing (Stage 2)	Follow-ups			Total
			First (Stage 3)	Second (Stage 4)	Phone (Stage 5)	
Cost Item:						
Labor[a]	$567.60	$ 570.40	$215.92	$253.20	$200.00	$1,807.12
Postage	104.23	544.38	62.78	171.36		882.75
Telephone[b]					22.24	22.24
Supplies[c]	7.45	24.83	2.07	5.83		40.18
TOTAL	$679.28	$1,149.61	$280.77	$420.39	$222.24	$2,752.29
Number of questionnaires sent		859		258	130	859
Number of questionnaires usable		606		123	68	797
Cost per usable response[d]		$1.90		$3.42	$3.27	$3.45

[a] Includes secretarial labor and a graduate assistant.

[b] 318 minutes.

[c] Return envelopes and stationery.

[d] Usable responses defined as including any information returned in a letter, postcard, telephone call, etc., which, at a minimum, allowed the corporation to be classified as a corporation farm, noneligible, or nonrespondent.

tribution of firm types. Interestingly, the third wave contained a disproportionate number of real estate firms. Based on the cover letter included with the questionnaires, the firms apparently concluded that they were not agricultural corporations, could not contribute to the study, and thus ignored the first two follow-ups.[10] The personal phone call, however, convinced them to cooperate.

Respondents versus nonrespondents

The 83 nonrespondents were different from the respondents. Although a direct comparison of means of gross and net incomes (as reported for tax purposes) was not possible due to statistically different variances, generally the nonrespondents' incomes were much smaller than respondents'. They were also much more homogeneous in characteristics than the responding corporations. Due to their small number, their exclusion made little significant impact on the overall descriptive statistics.

Questionnaire completeness

To discover if the efforts to draw out the final responses had an adverse effect on questionnaire completeness, data on the number of nonresponses per questionnaire were analyzed. No significant differences in questionnaire completeness existed between firms responding to the first mailing and those prodded by mail follow-ups or the telephone stimuli.[11]

The costs

Cost per usable response ($3.45) was very low in relation to other methods of data gathering (Table 3). The survey research laboratory at the University of Wisconsin estimates that an equivalent personal interview would cost more than 20 dollars per response. A telephone interview would cost two to three dollars per schedule—but with lower response rates.

Summary

Any questionnaire is an imposition on the respondent. Mailed questionnaires face special difficulties in regard to response rates. The literature on the subject suggests that techniques for improving response require finesse in overcoming the respondent's natural resistance.

This study attempted to develop procedural techniques which personalized contacts with respondents and neutralized depersonalizing aspects. Efforts were made to convince the respondent that he would benefit personally by completing the questionnaire. The procedure included an advance letter, hand-stamped mailings, special delivery handling, and mail and telephone follow-up.

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[10] This assumption proved to be correct since they were eventually classified as nonagricultural corporations and excluded from the analysis.

[11] This analysis took into account nonresponse due to: (1) poor question design (assumed from large numbers of nonresponses), (2) nonapplicability or irrelevance of questions or sections to a particular firm (evident from question-by-question analysis), and (3) differences in motivation or cooperation (assumed from differences between waves). Nonresponses were well distributed over the three response waves. The Chi square value of 2.9 with 8 degrees of freedom results in accepting the null hypothesis at the .05 level of probability.

The methods employed achieved a response rate of 91 percent. The study indicates that mailed questionnaire response rates can be significantly improved over the 50 percent norm and the mailed questionnaire can be an efficient method of data collection. Cost per response was considerably lower than a personal interview.

A significant difference existed between early and later respondents and apparently between respondents and nonrespondents. *Hence, in this case, the efforts made to collect the reluctant respondents paid off in a more representative sample. Questionnaire quality and completeness did not deteriorate as further stimuli were applied to the nonrespondent to force a response.*

By utilizing appropriate procedures, researchers can have greater confidence in the mailed questionnaire as a research tool.

References

[1] Backrock, Stanley D., and Harry M. Scable, "Mailed Questionnaire Efficiency: Controlled Reduction of Non-response," *Public Opinion Quart.* 31:265–271, Summer 1967.

[2] Backstrom, Charles H., and Gerald D. Hursh, *Survey Research*, Evanston, Northwestern University Press, 1963.

[3] Bartlett, M. S., "Properties of Sufficiency and Statistical Tests," *Proceedings of the Royal Society of London*, A, 160, 1937, p. 268.

[4] Boek, Walter E., and James H. Lade, "A Test of the Usefulness of the Postcard Technique in a Mail Questionnaire Study," *Public Opinion Quart.* 27:303–306, Summer 1963.

[5] Brodt, Kenneth, "The Usefulness of a Postcard Technique in a Mail Questionnaire Study," *Public Opinion Quart.* 19:218–222, Summer 1955.

[6] Clausen, John A., and Robert M. Ford, "Controlling Bias in Mail Questionnaires," *J. Am. Stat. Assoc.* 42:449, 1957.

[7] Deming, W. E., "On Errors in Surveys," *Am. Sociological Rev.* 9:359–369, 1944.

[8] Donald, Marjorie N., "Implications of Nonresponse for the Interpretation of Mail Questionnaire Data," *Public Opinion Quart.* 24: 99–114, Spring 1960.

[9] Eckland, Bruce K., "Effects of Prodding to Increase Mail-back Returns," *J. Applied Psychology* 49:165–169, June 1965.

[10] Ferber, Robert, *Statistical Techniques in Market Research*, New York, McGraw-Hill, Inc., 1949.

[11] ———, "The Problem of Bias in Mail Returns: A Solution," *Public Opinion Quart.* 12:669–676, 1948.

[12] ———, "Item Non-response in a Consumer Survey," *Public Opinion Quart.* 30:399–413, Fall 1966.

[13] Ferness, Abbott L., "A Note on Stimulating Response to Questionnaires," *Am. Sociological Rev.* 16:247, 1951.

[14] Frankel, Lester, R., "How Incentives and Subsamples Affect the Precision of Mail Surveys," *J. Advertising Res.* 1:1–5, Sept. 1960.

[15] Goode, William J., and Paul K. Hatt, *Methods in Social Research*, New York, McGraw-Hill, Inc., 1952.

[16] Gullahorn, John T., and Jeanne E. Gullahorn, "Increasing Returns from Non-respondents," *Public Opinion Quart.* 23:119–121, Spring 1959.

[17] Mason, Wards, Robert J. Dressel, and Robert K. Bain, "An Experimental Study of Factors Affecting Response to a Mail Survey of Beginning Teachers," *Public Opinion Quart.* 25:296–299, Summer 1961.

[18] Mayer, Charles S., and Robert W. Pratt, "A Note on Non-response in a Mail Survey," *Public Opinion Quart.* 30:637–646, Winter 1966.

[19] McDough, Edward C., and A. Leon Rosenblum, "A Comparison of Mailed Questionnaires and Subsequent Structural Interviews," *Public Opinion Quart.* 29:131–136, Spring 1965.

[20] Nichols, Robert C., and Mary Alice Meyer, "Timing Postcard Follow-ups in Mail Questionnaire Surveys," *Public Opinion Quart.* 30:306–307, Summer 1966.

[21] Plug, Stanley C., "Explanations for a High Return Rate on a Mail Questionnaire," *Public Opinion Quart.* 27:297–298, Summer 1963.

[22] Robins, Lee, "The Reluctant Respondent," *Public Opinion Quart.* 27:276–286, Summer 1963.

[23] Roeher, G. Allan, "Effective Techniques in Increasing Response to Mailed Questionnaires," *Public Opinion Quart.* 27:299–302, Summer 1963.

[24] Selltiz, Claire, Marie Jabada, Morton Deutsch, and Stuart W. Cook, *Research Methods in Social Relations*, New York, Holt, Rinehart and Winston, 1964.

[25] Sudman, Seymour, *Reducing the Cost of Surveys*, Chicago, Aldine Publishing Company, 1967.

[26] Vincent, Clark E., "Socioeconomic Status and Familiar Variables in Mail Questionnaire Response," *Am. J. Sociology* 69:647–653, May 1964.

[27] Wales, H. G., and Robert Ferber, *A Basic Bibliography on Marketing Research*, 2nd ed., American Marketing Association, 1963.

[28] Wallace, David, "A Case for and Against Mail Questionnaires," *Public Opinion Quart.* 18:40–52, Spring 1955.

[29] Young, Pauline V., *Scientific Social Surveys and Research*, New Jersey, Prentice-Hall Inc., 1966.

Technological Change and Relative Factor Shares in Indian Agriculture: An Empirical Analysis*

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Distribution of sectoral gains between labor and nonlabor input factors attains importance in view of the growing concern about rural poverty and unemployment despite recent increases in output and total revenue in Indian agriculture. Using cross section data, this study aims at measuring changes in the relative factor shares.

THE last few years have brought a perceptible technological transformation of agriculture in India and other Asian countries.[1] This transformation has become known as "the green revolution," characterized by biological-mechanical[2] innovations [21] that have rapidly increased output and total net revenue of the agricultural sector.

Despite increased income of the agricultural sector in LDC's, there has been growing concern with rural poverty and unemployment. In India, for example, recent studies show an increase in the proportion of rural population below the poverty line [2, 8, 16]. Landless agricultural laborers and small farmers constitute the bulk of the rural poor. Small farmers also derive a large portion of their income from hiring out surplus family labor. Quantitative projections of the growth of employment in the nonagricultural sector do not show any significant potential for the absorption of the growing agricultural labor force [24]. These circumstances have created a special interest in the relationship between growth in output and factor shares, particularly labor's share, within the agricultural sector in LDC's. The basic question is whether the undergoing technological change will increase employment potential in agriculture so that landless laborers will find adequate employment in agriculture.

Much research has been devoted to empirical verification of the relationship between the absolute demand for labor and growth in agricultural output [4, 5, 12, 18, 23]. This paper, however, is concerned mainly with the changes in relative factor shares. Such changes are analyzed with application of the CES production function framework. The analysis also indicates the importance of various forces affecting relative income shares.

The Data

Changes in relative factor shares are analyzed in two regions in India: Ferozepur (Punjab) and Muzzaffernager (Uttar Pradesh).[3] The choice of these regions is dictated by availability of comparable data relating to pre-technological and post-technological change periods. Incidentally, these two regions are the most important contributors to the green revolution in wheat. Data used in the analysis were collected by the Directorate of Economics and Statistics, Government of India. These data were derived from cost-accounting surveys conducted on a cross section sample of farmers in the two regions at two points of time: the mid-1950's and late 1960's, conforming with an *a priori* classification of pre-technological and post-technological change periods in Indian agriculture.

The surveys conducted in the mid-1950's (1954–57) included 200 farmers, while the surveys of the late 1960's (1966–70) included 150 farmers for each region. Farmers were selected on a stratified random sample basis. In the absence of time series data, these cross-section observations are the only source of material for studies dealing with the factor shares in Indian agriculture.

Since the published data (in the form of eight

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* Journal Paper J-7360 of the Iowa Agriculture and Home Economics Experiment Station, Ames. Project number 1558. We are grateful to an inimical friend who was also one of the *Journal* referees for his extremely useful suggestions in improving this paper.

[1] There has been a temporary setback in agricultural production during the 1971–72 agricultural year because of extremely bad weather conditions, but the high yielding varieties have gained wide acceptance.

[2] For a classification of innovation in agriculture and impact on factor demands, see Heady [9].

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[3] The Farm Management Surveys of 1955–56 included two districts: Amritsar (besides Ferozepur) in Punjab, and Meerut (besides Muzzaffernagar) in Uttar Pradesh Survey. To have a large cross section sample of the area, this analysis uses the data of both the districts in the pre-technological change period.

Table 1. Percentage share of selected Indian states in sown area and in holdings of agricultural machinery

State	Net sown area (1964–65)	Holdings of agricultural machinery (1966)		
		Diesel engines	Electric pumps	Tractors
Andhra Pradesh	8.4	10.4	9.5	5.4
Gujarat	6.9	25.0	3.8	6.0
Maharashtra	13.2	32.5	9.7	6.0
Punjab (including Haryana)	5.6	1.8	2.3	28.7
Tamil Nadu	4.4	9.5	53.4	6.1
Uttar Pradesh	12.6	6.3	2.6	18.8
Other states and centrally administered territories	48.9	14.5	18.7	29.0
	100.0	100.0	100.0	100.0

Source: K. N. Raj [17].

class means) from the studies [11] have been found to contain aggregation bias, this analysis uses the actual farm-level data. Farm level data were available to the authors only for one year (Uttar Pradesh, 1956–57, and Punjab, 1955–56) of the pre-technological change period and two years (1967–69) of the post-technological change period. The two data sets of each of the regions have been used for the following analysis. Changes in relative factor shares, particularly in labor's share, in Uttar Pradesh and Punjab should also reflect the impact of tractor use. Uttar Pradesh and Punjab account for a sizeable percentage share of the tractors in use in Indian agriculture (Table 1).

Limitations of Earlier Studies With Cobb-Douglas Framework

Production function studies for agriculture in developing economies have assumed the Cobb-Douglas form to be logically appropriate to the data. Very little effort has been made to verify the actual value of the elasticity of substitution,[4] with the exception of a study by Yotopoulos *et al.* [25]. In the Cobb-Douglas form, the relative factor shares remain unchanged, even with a change in relative factor prices and factor ratios (substitution between factors), because the elasticity of substitution between inputs is forced to unity. Technological change is expressed in the Cobb-Douglas function by a change in the partial elasticities of production, and/or a change in the intercept term in the function (A). Technological change alters relative factor shares only when it changes the ratios of the partial elasticities of production. Bardhan [3] has recently tried to verify the elasticity of substitution between land and labor by means of a "Kmenta approximation" for some of the post-technological change data used in the present study (data sets relating to 1967–69). The elasticity of subsitution between land and labor inputs was found to be significantly different from unity. This pioneering study throws some doubt on the elasticity of substitution assumption underlying the studies with Cobb-Douglas production functions.

Furthermore, the prices of both labor and capital inputs have increased in recent years for both regions studied. Contrary to the expectation of "surplus labor theorists," wage rates in the two regions have increased much faster than the prices of major capital goods such as tractors and implements. Some indications of changes in relative factor prices are available in the fragmentary evidence in Table 2. Average daily wage rates of adult laborers nearly doubled in Uttar Pradesh and tripled in Punjab between 1961–62 and 1968–69. During the same period prices of two brands of tractors (Eicher and Tafe, the only ones being produced in 1961–62) increased by only 50 percent. Prices of other brands of tractors (production of these started in later years) have risen very little since the first year of production as compared with wage rates during the same period. Interest rates on long term capital also have been very low [19]. Two explanations have been offered recently for such a rapid rise in wage rates: Rao [19] offers a Ricardian explanation that prices of wage goods have increased because cultivation has been extended

Table 2. Some indicators of relative factor prices

Indicator	Unit	1961–62	1964–65	1968–69
Wage Rates (per day):				
Uttar Pradesh	Rs.	1.33	1.74	2.61
Punjab	Rs.	2.39	3.02	6.23
Tractor Prices (different brands)				
Eicher (27 H.P.)	Rs.	11,900	—	17,460
TAFE (35 H.P.)	Rs.	14,450	—	21,141
Hindustan (50 H.P.)	Rs.	—	17,500	22,350
Escorts (27 H.P.)	Rs.	—	13,100	13,840
Escorts (37 H.P.)	Rs.	—	15,400	17,910
Hindustan (35 H.P.)	Rs.	—	12,500	15,710
International (35 H.P.)	Rs.	—	16,380	19,570
Percentage Ratios of Indices of Fertilizer Prices to Cereal Prices Indices (1961–62 = 100)		100.0	79.9	71.0

Sources: (1) Tractor prices and wage rates for 1961–62 and 1968–69 in Uttar Pradesh [19]; (2) wage rates in Punjab [10]; (3) wage rates for 1964–65 in Uttar Pradesh [13]; (4) the ratios of indices of fertilizer to cereal prices are worked out from Economic Survey of Agriculture Ministry of Food and Agriculture 1968–69.

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[4] There have been a large number of studies with Cobb-Douglas production function. For studies relating to Indian agriculture, see Srivastava *et al.* [22].

to the marginal lands; Herdt and Baker [10] argue that the supply curve of labor is no longer perfectly elastic in these areas.

Empirical Estimates of the Parameters Affecting Relative Income Shares

Arrow *et al.* [1] formulated the CES production function which eliminates the assumption of an elasticity of factor substitution equal to unity. The CES function is

$$Q = \gamma\{\delta K^{-\rho} + (1 - \delta)L^{-\rho}\}^{-1/\rho} \tag{1}$$

where Q, K, and L denote output, capital, and labor, respectively; γ is a technological parameter, δ is a distribution parameter, and ρ is the factor substitution parameter. Brown [6, 7] has shown that the relative shares of capital and incomes, in terms of the CES function, depend on the ratio of labor to capital, on capital intensity, and elasticity of substitution parameters. The share of labor relative to capital under marginal productivity equilibrium can be expressed as:

$$S = \frac{wL}{qK} = \frac{1 - \delta}{\delta}\left(\frac{q}{w}\right)^{\sigma - 1} \tag{2}$$

where

S = the ratio of labor income to capital income,
w = wage rate per unit of labor,
q = rental per unit of capital,
$1 - \delta/\delta$ = labor intensity,

and

σ = elasticity of substitution $(1/1+\rho)$.

The parameters affecting relative income shares were empirically estimated. Brown [7] has derived the estimating form of the equation using time series data. In the absence of time series data, the estimating equation becomes as follows:

$$\log\left(\frac{L}{K}\right) = \sigma \log\left(\frac{1 - \delta}{\delta}\right) + \sigma \log\left(\frac{q}{w}\right) + \epsilon \tag{3}$$

where

L = human labor (adult man days),[5]
K = value of fixed assets on the farm in rupees (includes value of land, machinery, and implements),
w = wage rate per day in rupees (derived by dividing total wage bill by total number of days),
q = rental of capital per unit in rupees (derived by dividing the share of capital in value added on each farm by the total amount of capital on the farm; share of capital in value added has been calculated by subtracting the wage bill and expenditures on seed, fertilizers, and irrigation from the total output; expenditures on seed, fertilizers, and irrigation are the measures for intermediate inputs),

and

ϵ = error term.

The logarithm of the share of labor relative to capital in value added can be obtained by subtracting $\log(q/w)$ from the estimated equation (3). It gives all the components of the relative factor shares. The logarithm of the labor intensity parameter $(1-\delta/\delta)$ is derived from the estimated intercept term. The logarithm of S can be expressed as [7]:

$$\log S = \sigma \log\left(\frac{1 - \delta}{\delta}\right) + (\sigma - 1)\log\left(\frac{q}{w}\right) + \epsilon \tag{4}$$

where all the terms are as defined previously.

It is, however, well known that there are imperfections in the labor market in a dual agrarian economy such as India's [20]. Although the proportion of hired labor to total labor is very low on the small farms, it is relatively high on the large farms. Family labor usually is willing to work on the family farm at less than the going market wage rate, yet the surveys impute the value of family labor at the going market wage rate. This is one of the main imperfections in the labor market for a dual agrarian economy. To take out the effect of this imperfection in the labor market, a farm size dummy variable was added in equation (3). Also, since two years of post-technical change data were used, a dummy variable was added to account for the time differences. The final estimating form of equation (3) is as follows:

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[5] Female and child labor days have been converted into adult man days by using the conversion factors applied in the studies [11].

Table 3. Estimated parameters of equation (5)

Region	Year	$\log\left(\frac{1-\delta}{\delta}\right)$	σ	ξ_1	ξ_2	$d.f.$	R^2	$\log\left(\frac{q}{w}\right)$	Actual log S	Computed log S
Uttar Pradesh	1956–57	−1.8002* (0.0366)	0.2453* (0.0308)	—	−0.0077 (0.0292)	191	0.4582	−1.0857* (0.4597)	−0.9730	−0.9809
	1967–69	−1.8259* (0.0767)	0.4855* (0.0506)	0.0469* (0.0144)	−0.0918* (0.0142)	295	0.6511	−1.5115* (0.1473)	−1.0862	−1.0481
Punjab	1955–56	−1.9513* (0.0674)	0.1744* (0.0355)	—	−0.0277 (0.0240)	192	0.4204	−1.7690* (0.3247)	−0.3013	−0.3141
	1967–69	−2.1155* (0.1171)	0.2755* (0.0472)	0.0672* (0.0243)	−0.1347* (0.0457)	292	0.6052	−2.1691* (0.2681)	−0.5338	−0.5440

* Significantly different from zero and one at 1 percent probability level.

$$\log\left(\frac{L}{K}\right) = \sigma \log\left(\frac{1-\delta}{\delta}\right) + \sigma \log\left(\frac{q}{w}\right) + \xi_1 d_1 + \xi_2 d_2 + \epsilon \tag{5}$$

where

d_1 = year dummy variable. It takes the value zero for the observations of 1967–68 and value one for the observations of 1968–69 for each of the two regions. This variable has been included only in the case of post-technological change data.

d_2 = farm size dummy variable. It takes the value zero for the observations relating to the farmers having below 10 acres of land area, and value one for the farmers having 10 acres or more.[6]

Estimated parameters of equation (5) are presented in Table 3. All the parameters, except for the farm size dummy variable in the mid-1950's, are significantly different from zero and one at the 1 percent probability level. However, before the changes in share of labor relative to capital were computed on the basis of estimated parameters at different points of time, it was necessary to test the null hypotheses:[7] $\log(1-\delta/\delta)_{1955-56} = \log(1-\delta/\delta)_{1967-69}$, $\sigma_{1955-56} = \sigma_{1967-69}$, and $\log(q/w)_{1955-56} = \log(q/w)_{1967-69}$. All the parameters in 1967–69, except $\log(1-\delta/\delta)$ in Uttar Pradesh, are significantly different from the parameters in 1955–56 at the 1 percent probability level. The parameter $\log(1-\delta/\delta)$ for Uttar Pradesh in 1967–69 is significantly different from the 1956–57 estimates at the 10 percent probability level. Thus there has been a significant change in all the relevant parameters.

It can be seen that there has been a decline in the labor intensity and factor price ratio (q/w). But there has been an increase in the elasticity of substitution between capital and labor in both regions included in this study. A decline in the parameter of labor intensity and factor price ratio causes a decline in the share of labor relative to capital [6, 7]. Similarly an increase in the elasticity of substitution also causes a decline in the share of labor relative to capital (when labor intensity and factor price ratios are less than unity). Expected changes in the share of labor relative to capital (S) have actually taken place (Table 3). It can also be noted that the computed relative share of labor (computed on the basis of estimated parameters) is very close to the actual share. The error in the computed estimates of S is less than 1 percent of the actual estimates in all cases. It is interesting to note that as compared to Uttar Pradesh, there has been a marked decline in S in the case of Punjab. As shown in Table 1, Punjab has undergone a rapid mechanization as compared to the rest of the regions in India.

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[6] The division of less than 10 acres and 10 acres and above is also suggested by a study on the relative efficiency of farm size groups [14].

[7] In testing the null hypothesis, the pooled standard errors are computed by not assuming that variances of two populations are equal. It can be expressed as:

$$SE = \sqrt{s_1^2/n_1 + s_2^2/n_2}$$

where

SE = pooled standard errors,

s_1 = computed standard error for the parameter in the mid-1950's,

s_2 = computed standard error for 1967–69,

n_1 = number of observations in the mid-1950's sample,

and

n_2 = number of observations in the 1967–69 combined sample.

Importance of Various Forces Affecting Relative Income Shares

To determine the importance of forces affecting the relative income shares, the effect of a unit change in each of the three parameters—elasticity of substitution (σ), factor price ratio ($\log [q/w]$), and labor intensity ($1-\delta/\delta$)—on $\log S$ (ratio of labor share to capital share) was evaluated (Table 4). It was determined that a unit change in σ is the most important contributor to the change in the relative share of labor ($\log S$) at both points of time in Uttar Pradesh as well as Punjab. The other two forces are, according to importance, $\log (q/w)$ and $\log (1-\delta/\delta)$. Absolute importance of parameters σ and $\log (1-\delta/\delta)$ has increased in 1967–69 as compared to the mid-1950's (Table 4). But the absolute importance of $\log (q/w)$ has declined in the 1967–69 period as compared to the mid-1950's. Since capital has been the expanding factor, the rise in σ has contributed to a decline in the relative share of labor. An expanding use of capital has been encouraged by the decline in the factor price ratio (q/w) in addition to noneconomic factors [17]. Expansion in capital use is reflected by a strong demand for tractors, particularly in the Punjab.

Implications of the Decline in Relative Share of Labor in Indian Agriculture

The evidence presented above indicates that there has been a decline in the relative factor share of labor in value added. This decline has occurred despite a marked increase in the wage rate, particularly in peak season. It seems to indicate that technological change has been labor-saving in nature. What are the implications of this change for the landless laborers who primarily depend on wage employment in agriculture for subsistence? This question should be examined in relation to the increase in labor force in the category of landless laborers.

Agricultural labor force has been divided between the cultivators and agricultural laborers in Indian Census publications.[8] Census data indicate that the labor force in the category of cultivators and nonagriculture marginally declined or at best remained constant between 1961 and 1971.[9] There was an increase, however, in the labor force in the agricultural laborers category in all the states in India. How can one explain the increases in agricultural laborers and marked increases in wage rates in recent years? The answer is that high yielding varieties of crops require planting and harvesting operations to be completed in a very short period of time. This sharpened the peaks in labor demand and thereby created a shortage of labor during that period. The seasonal shortage of labor pushed the wage rates upward. But there was not much improvement in the demand for labor in the nonpeak season. Overall demand for labor did not increase in direct proportion to the increases in output because of a decline in the labor intensity of the new technology. Therefore, despite the peak season wage increases, the relative share of labor declined.

Table 4. Computed partial derivatives of log S

Region	Year	$\frac{\partial \log S}{\partial \sigma}$	$\frac{\partial \log S}{\partial \log (1-\delta/\delta)}$	$\frac{\partial \log S}{\partial \log (q/w)}$
Uttar Pradesh				
	1956–57	−2.8859	−0.2453	−0.7546
	1967–69	−3.3374	+0.4855	−0.5146
Punjab				
	1955–56	−3.7103	+0.1744	−0.8255
	1967–69	−4.2840	+0.2755	−0.7245

Technological change in agriculture has, left to itself, failed to improve relative income shares of agricultural laborers. Under these circumstances, apprehensions have been expressed over government policies to permit and aid mechanization in Indian agriculture [17, 19, 21]. Rao [19] has supported a policy of selective mechanization in the states like Punjab on the grounds that the prohibitive cost of biological energy and acute shortage of labor during peak season form serious constraints in increasing output in these areas. Also, use of tractors increases crop intensity and thereby increases output. But at the same time it is necessary to provide work to the landless laborers during the off-season to guarantee them a basic minimum income. To accomplish this task, a wide range of rural works programs has been suggested [8, 15]. These programs can lead to further increases in output and labor demands. Domestic food surpluses can be used to sustain the rural works programs. The State of Maharashtra in India has already taken the lead in this direction.

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[8] Only about 39 percent of landless laborers owned some land in 1961.

[9] A decline or constancy of labor force among the categories of cultivators and nonagricultural sector shows up primarily because of a sharp decline in female labor participation and a slight change in definition of female labor in the 1971 census.

References

[1] ARROW, K. J., H. CHENERY, B. S. MINHAS, AND R. SOLOW, "Capital-Labor Substitution and Economic Efficiency," *Rev. Econ. & Stat.* 43:225–250, Aug. 1961.

[2] BARDHAN, PRANAB K., "On the Minimum Level of Living and the Rural Poor," *Indian Econ. Rev.* 5 (New Series):129–136, April 1970.

[3] ———, "Size, Productivity and Returns to Scale: An Analysis of Farm Level Data in Indian Agriculture," paper presented at a conference at Food Research Institute, Stanford University, Dec. 1971.

[4] BILLINGS, MARTIN H., AND ARJAN SINGH, "Labour and the Green Revolution," *Econ. & Pol. Wkly., Rev. of Ag.* 4:A221–224, Dec. 1969.

[5] ———, *Agriculture and Technological Change in Maharashtra, 1968–84*, New Delhi, Ag. Econ. Division, USAID, April 1970, mimeo.

[6] BROWN, MURRAY, *On the Theory and Measurement of Technological Change*, Cambridge, Cambridge University Press, 1966.

[7] ———, AND JOHN S. DECANI, "Technological Change and Distribution of Income," *International Econ. Rev.* 4:289–309, Sept. 1963.

[8] DANDEKAR, V. M., AND N. RATH, "Poverty in India I and II," *Econ. & Pol. Wkly.* 6:25–48, Jan. 2–9, 1971.

[9] HEADY, EARL O., "Basic Economic and Welfare Aspects of Farm Technological Advance," *J. Farm Econ.* 21:293–316, May 1949.

[10] HERDT, ROBERT W., AND EDWARD A. BAKER, "Agricultural Wages, Production and High-Yielding Varieties," *Econ. & Pol. Wkly., Rev. of Ag.* 7:A23–30, March 1972.

[11] India, Government of, *Studies in Farm Management*, various reports for the years 1954–57, 1967–68, and 1968–69 for Punjab; and for the years 1954–57, 1966–67, 1967–68, and 1968–69 for Uttar Pradesh, New Delhi, 1954 through 1970.

[12] JOHNSTON, BRUCE F., AND JOHN COWNIE, "The Seed-Fertilizer Revolution and Labor Force Absorption," *Am. Econ. Rev.* 59:569–582, Sept. 1969.

[13] KRISHNAJI, N., "Wages of Agricultural Labour," *Econ. & Pol. Wkly., Rev. of Ag.* 6:A148–151, Sept. 1971.

[14] LAU, L. J., AND P. A. YOTOPOULOS, "A Test for Relative Efficiency and Application to Indian Agriculture," *Amer. Econ. Rev.* 61:94–109, March 1971.

[15] LELE, UMA J., AND JOHN W. MELLOR, "Jobs, Poverty and the 'Green Revolution,'" *International Affairs* 48:20–32, Jan. 1972.

[16] MINHAS, B. S., "Rural Poverty, Land Redistribution and Development Strategy: Facts and Policy," *Indian Econ. Rev.* 5 (New Series):97–128, April 1970.

[17] RAJ, K. N., "Mechanization of Agriculture in India and Sri Lanka (Ceylon)," *Int. Labor Rev.* 106:315–334, Oct. 1972.

[18] RAO, C. H. HANUMANTHA, "Farm Mechanization in Labour-Abundant Economy," *Econ. & Pol. Wkly* 7:393–400, Feb. 1972.

[19] ——, "Green Revolution and Labour's Share in Output," *Agr. Situation in India* 27:283–286, Aug. 1971.

[20] SEN, A. K., "Peasants and Dualism With or Without Surplus Labor," *J. Pol. Econ.* 74:425–450, Oct. 1966.

[21] SRIVASTAVA, UMA K., ROBERT W. CROWN, AND EARL O. HEADY, "Green Revolution and Farm Income Distribution," *Econ. & Pol. Wkly., Rev. of Ag.* 6:A163–172, Dec. 1971.

[22] SRIVASTAVA, UMA K., VISHNUPRASAD NAGADEVARA, AND EARL O. HEADY, "Resource Productivity, Returns to Scale and Farm Size in Indian Agriculture," to be published in *Australian J. Agr. Econ.*

[23] THORBECKE, E., AND E. STOUTJESDIJK, *Employment and Output—A Methodology Applied to Peru and Guatemala*, Development Center Studies Employment Series 2, Paris, OECD, 1971.

[24] TURNHAM, DAVID, *The Employment Problems in Less Developed Countries—A Review of Evidence*, Development Center, Paris, OECD, June 1970.

[25] YOTOPOULOS, PAN A., L. J. LAU, AND K. SOMEL, *Food Research Institute Studies* (1970), pp. 43–55.

Estimating Educational Production Functions for Rural High Schools: Some Findings

RICHARD F. BIEKER AND KURT R. ANSCHEL

This study construed the formal educative process of students in five rural high schools in Kentucky in a production function context. The student was used as the basic observational unit and the curriculum as the basic educative unit. Production relationships were found to be significantly different between curricula.

IN 1970 President Nixon asked the question, "What makes a good school?" The old answer was a school that maintained a "high standard of plant and equipment; that had a reasonable number of children per classroom; whose teachers had good college and often graduate training; a school that kept up to date with curriculum developments, and was alert to new techniques in instruction." As the President knew, this is no longer a satisfactory answer. Educational research has "demonstrated that this direct, uncomplicated relationship does not exist" [11, pp. 2–3]. As a result researchers from many disciplines are attempting to find a new answer to the question.

One of the more promising approaches has entailed applying firm theory to the educational process. The school is viewed as a productive system in which certain factors are applied to achieve known, desired results. This study construes the formal educative process in the production function context as have previous studies [1, 4, 8, 9, 12, 14]. However, instead of using the school district as the basic educative and observational unit, the study denotes the student as the basic observational unit and the curriculum as the basic educative unit. The objective of the study is to determine whether production relationships differ significantly between different curricula within rural high schools when a single standardized achievement test is used to measure achievement in all curricula. More basically, the study seeks to determine whether the quality or efficiency of multiple-curriculum high schools can be evaluated by the use of a single objective function. Results of standardized achievement tests have been the most commonly used measures of quality or output in estimating production and cost functions for schools and school districts [1, 4, 9, 12]. The validity of such estimates is clearly dependent upon the validity of using a single standardized achievement test as the sole measure of school (district) quality or output.

The Model

It is hypothesized that the educational achievement of an individual student during a specified educative period depends upon the level of resources invested in the student by the school system, the student's innate ability, the student's motivation, and the extent to which the student's family supports and complements the formal educative process. In theory the formal educative process can be represented as a function:

$$A = f(X_1, X_2, X_3, X_4, X_5, X_6)$$

where

A = student achievement as measured by the Stanford Achievement Test. Two measures of achievement are used: the absolute change in the student's achievement during the educative period $(A_t - A_{t-1})$, and the relative change in the student's achievement during the educative period $((A_t - A_{t-1})/A_{t-1})$

X_1 = per pupil expenditure on guidance, teaching, and administrative personnel during the educative period $t-(t-1)$,

X_2 = per pupil stock of plant facilities available at time $t-1$,

X_3 = per pupil stock of instructional equipment available at time $t-1$,

X_4 = student mental ability as measured by the Otis-Lennon Mental Ability Test,

X_5 = a scaled measure of student motivation,

and

X_6 = parent's average grade attainment.

Specification of achievement in terms of absolute change $(A_t - A_{t-1})$ assumes that the stu-

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dent's starting point does not significantly affect his rate of incremental achievement during the specified educative period. On the other hand, the use of relative change in student achievement assumes that the student's starting point does significantly affect his rate of incremental achievement. The level of the student's achievement (A_t) is not used. Such a measure assumes that a student's educational experience (e.g., the quality of the school that he attends) after time $t-1$ does not differ significantly from his educational experience before time $t-1$. Such an assumption is not warranted.

Use of expenditure variables is only one of several ways to measure school inputs. The advantage of using expenditure variables is that they are more easily quantifiable and more meaningful from a policy standpoint than quality variables. It is probably reasonable to assume that, on the average, there is a significant positive correlation between the quality of inputs and their cost. Use of per pupil measures of expenditure is justified in this study because of the limited variation in the teacher (classroom)-class ratio and average class size of the sample schools. Also, because of the limited variation in average daily attendance among the sample schools, the model assumes no economies or diseconomies of scale.

In addition to school input variables, a student's educational achievement depends upon his innate ability. In a production function context, an ideal measure of ability would be one that is completely independent of the measure used for educational achievement. In practice, however, two completely independent measures are difficult to generate. Since achievement tests and mental ability tests tend to measure the same thing [5], to the extent that the two measures overlap they are not truly independent as required by the ordinary least squares model used in this analysis [10]. This element of simultaneity is reduced by measuring ability at a point in time and achievement in an incremental context.

Another important factor affecting the student's achievement is his motivation. The basis of the motivational scale developed in this study is a battery of five questions. The relative levels of motivation of the students were ordered, and a unidimensional eight-point scale was constructed by the Guttman procedure.[1] For the rationale of Guttman Scale analysis see Remmers [13, pp. 96–118].

Finally, the student's change in achievement during the specified educative period depends upon the extent to which his family supports and complements the formal educative process during that period. Parent's average grade attainment is used as a proxy for the family's support of the formal education process.

While the above functional relationship is formulated as a general one for all students in a school, different curricula within a school are designed to generate different skills or have different objective functions. In this study a separate objective function is denoted for three curricula: academic, general, and vocational. The classification with respect to curriculum for the individual student was made on the basis of the types of courses he was enrolled in during the specified educative period.

Although a different objective function is denoted for each curriculum, a single test, the basic high school battery of the Stanford Achievement Test, is used to measure the achievement of students in all three curricula. Since this test measures achievement in basic academic skills, it measures a greater proportion of the skills generated in the academic curriculum than in the general and vocational curricula. Accordingly, it is posited that the relationship between inputs into the formal educative process and incremental student achievement differs between the students enrolled in the academic curriculum and those enrolled in the general and vocational curricula.

The Data and Findings

Data used in the analysis were obtained for 226 11th grade students in five high schools in rural Kentucky.[2] The educative period for these students is defined as the 1967–68 and 1968–69 school years. Group and common means as well as the results of one-way analysis of variance tests are summarized in Table 1. These results indicate that the absolute change in achievement is significantly different between the three

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[1] The items used for establishing the motivation dimension met the criteria for scalability as specified by Guttman.

[2] At the time of the survey the population of 11th grade students enrolled in these five schools was 277, but because of incomplete test data, 51 were not included in the analysis. Twenty-three of the students moved into the school districts after the first achievement test was administered. The remainder were absent when either one or both of the achievements tests were administered. The deleted students appeared to be randomly distributed among the three curricula.

Table 1. Curriculum group means, common means, and F ratios for 226 11th grade students in five high schools in Kentucky for the 1967–68 and 1968–69 school years[a]

Variable	Curriculum Mean Values			Common Mean	F Ratio
	Academic N=44	Vocational N=86	General N=96		
$A_t - A_{t-1}$	29.8	22.8	23.0	24.2	2.63*
$\frac{A_t - A_{t-1}}{A_{t-1}}$	.144	.116	.131	.128	.96
X_1	507.0	532.8	508.2	517.1	1.86
X_2	1238.2	1053.8	994.2	1064.4	1.51
X_3	157.1	274.5	203.6	221.4	29.44***
X_4	97.6	96.1	91.7	94.5	4.30**
X_5	5.9	6.0	5.9	5.9	.20
X_6	8.0	8.3	7.8	8.0	1.88

* Significant at .10 level.
** Significant at .05 level.
*** Significant at .01 level.
[a] See text for definition of variables.

curricula at the .10 level. The relative change is not significantly different partly because of differences in the initial levels of achievement between curricula. Average absolute change in achievement for students in the academic curriculum is 29 percent higher than the average for students in the general curriculum and 30 percent higher than the average for students in the vocational curriculum. Average relative change in achievement for students in the academic curriculum is 9 percent greater than the average for students in the general curriculum and 24 percent higher than the average for students in the vocational curriculum.

Of the three school inputs, only per pupil stock of instructional equipment (X_3) is significantly different among the three curricula. The average per pupil stock for students in the vocational curriculum is 35 percent higher than the average for students in the general curriculum and 75 percent higher than the average for students in the academic curriculum.

Average mental ability (X_4) of students in the general curriculum is significantly different from the mental ability of students in the other two curricula. However, the average for students in the academic curriculum is not significantly different from the average for students in the vocational curriculum. These findings suggest that the general curriculum is a catchall curriculum for those students not selecting (or selected by) the vocational or academic curricula. The other student variable, motivation (X_5), is not significantly different among the three curricula. Finally, comparisons indicate that the family background of the students as measured by parents' average grade attainment (X_6) is not significantly different between the three curricula.

Results of fitted regression equations for both the absolute and relative change in achievement by curriculum are shown in Table 2.[3] The equations are linear in terms of the logarithms of the variables. The findings with respect to the school variables support the hypothesis that the model is more appropriate for explaining change in achievement of students in the academic curriculum than that of students in vocational and general curricula. The coefficients of all of the school variables are positive in the equations for the academic curriculum. While not significant in the log form, X_1 is significant at the .01 level in the linear form, but in this form X_3 is not significant. In contrast to the academic curriculum, the school variables X_2 and X_3 are not significant in either equation for the general and vocational curricula, and the signs of X_1 are consistently negative.

While the relationship between ability and incremental achievement differs between students in the academic curriculum and students in the general and vocational curricula, the difference is in the opposite direction of that expected. Coefficients in the equations for the general and vocational curricula are statistically significant while those for the academic curriculum are not significant. The initial supposition that lack of significance in the equa-

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[3] Deletion of insignificant variables from the equations did not significantly change the regression coefficients or the standard errors of the remaining variables.

Table 2. Fitted regression equation for the relative and absolute changes in student achievement in basic subjects by curriculum[a]

Curriculum and Measure of Achievement	Intercept	Per Pupil Expenditure on Teacher Guidance and Administrative Personnel (X_1)	Per Pupil Stock of Plant (X_2)	Per Pupil Stock of Instructional Equipment (X_3)	Student Mental Ability (X_4)	Student Motivation (X_5)	Parent's Average Grade Attainment (X_6)	R^2	Number of Observations
Academic									
I. $A_t - A_{t-1}$	−7.62	1.26 (1.54)	1.08** (2.66)	0.73* (2.21)	0.36 (0.26)	0.31 (0.59)	−0.33 (0.52)	.40	44
II. $\frac{A_t - A_{t-1}}{A_{t-1}}$	−6.09	1.12 (1.37)	1.21*** (2.96)	0.73* (2.21)	−1.53 (1.13)	0.42 (0.80)	−0.53 (0.85)	.39	
Vocational									
I. $A_t - A_{t-1}$	−2.34	−1.79 (1.53)	0.06 (0.12)	0.90 (1.40)	2.80** (2.30)	0.72 (1.33)	−0.14 (0.22)	.12	86
II. $\frac{A_t - A_{t-1}}{A_{t-1}}$	−1.14	−1.74 (1.45)	−0.04 (0.07)	0.89 (1.36)	1.26 (1.02)	0.64 (1.15)	−0.32 (0.51)	.06	
General									
I. $A_t - A_{t-1}$	−6.07	−1.45* (2.14)	0.61 (1.50)	0.44 (1.30)	4.17*** (3.67)	0.32 (0.79)	−0.18 (0.47)	.19	96
II. $\frac{A_t - A_{t-1}}{A_{t-1}}$	−4.96	−1.42* (2.09)	0.61 (1.47)	0.45 (1.30)	2.44* (2.13)	0.32 (0.77)	−0.22 (0.55)	.11	

* Significant at .05 level.
** Significant at .025 level.
*** Significant at .01 level.
[a] The equations are linear in terms of the logarithms of the variables. Figures in parentheses below the regression coefficients are standard values of t.

tions for the academic curriculum was caused by "topping out" on the achievement tests by the brighter students was dismissed after finding that students in the upper quartile with respect to mental ability did not have significantly different raw scores on either of the two achievement tests than students in the third quartile.[4] Nevertheless, several plausible explanations remain. Perhaps only some minimum level of ability is required for achievement in the academic curriculum, and once this level is attained other factors become more important in determining achievement. Possibly the academic curriculum is designed for the average student and the superior student is unable to capitalize on his inherent ability.

The signs of the coefficients for student motivation are positive for both equations in all three curricula. However, the coefficients are not significantly different from zero in any of the equations.

The coefficient for parents' average grade attainment (X_6) is not significant in any of the equations for any of the curricula. However, the sample variation about the mean of this variable is limited for all curricula. When sample observations are so clustered, it is questionable whether this variable captures the full effect of differences in family support of the formal educative process. Furthermore, stochastic and measurement errors exert greater leverage when observations are so clustered, causing the estimate to be less reliable.

The comparative explanatory power of the model is also indicated by the R^2 values. For the academic curriculum the model explains 40 percent of the variance in the absolute change in achievement and 39 percent in the relative change in achievement. The corresponding R^2 values for the general curriculum are 19 and 11 percent, and for the vocational curriculum 12 and 6 percent.

To test whether the sets of regression coefficients between the curricula are significantly different, i.e., whether the samples of the three groups belong to the same regression, the F statistic developed by Chow was used [3]. Results of the tests indicate that the set of coefficients for the academic curriculum is significantly different from the sets for the vocational and to a lesser degree the general curriculum. However, the set of coefficients for the general curriculum is not significantly different from the set for the vocational curriculum in either of the two equations.[5]

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[4] "Topping out" occurs when the ceiling built into a test, i.e., the maximum possible score, is not high enough for some of the students taking the test [9]. The F ratios obtained when testing for differences in A_t and A_{t-1} were 2.44 and 2.50, respectively.

Conclusion

While admittedly derived from a narrow data base, the empirical evidence presented in this study supports the hypothesis that there is no unique function to describe the relationship between high school inputs and product; rather each curriculum must be analyzed individually. This hypothesis is supported by two results of the analysis. First, the coefficients of the equations for the vocational curriculum and to a lesser degree the general curriculum differ significantly from those of the academic curriculum. This indicates that the relationship between inputs and product differ among the curricula, and the functions must be fitted separately. Second, the R^2 values for the vocational and general curricula were extremely low, indicating that achievement as measured by the Stanford Achievement Test is an inadequate and inappropriate measure of the products of these curricula. Although it is possible that low R^2 values reflect inadequate specification and measurement of the independent variables (and probably do to some extent), it is the contention of the authors that relatively high R^2 values for the academic curriculum imply the failure is in the measurement of product, not factors. Factors for the three curricula do not differ greatly in substance, only in quantity. Hence, it must be the product that is poorly measured.

It is conceded that a systematic delineation of the separate programs within local schools will not be an easy task. Construction of indices to measure the quality of these programs will be even more difficult. Nevertheless, the findings of this study indicate that these are the necessary first steps in developing a suitable methodology for evaluating the quality and efficiency of local school systems.

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[5] Values of the F ratios (2.14, 2.11) exceeded the critical value of 2.08 ($F_{.05}$; 7, 116) when equations for the academic curriculum were tested against equations for the vocational curriculum. When equations for the academic curriculum were tested against those for the general curriculum, the F ratios (1.72, 1.68) approached the critical value of 1.77 ($F_{.10}$; 7, 126). When the consistently insignificant variables (X_5, X_6) were deleted from the equations, the corresponding F ratios (2.78, 2.73) and (2.34, 2.24) exceeded the critical values of 2.29 ($F_{.05}$; 5, 120) and 1.90 ($F_{.10}$; 5, 130), respectively.

References

[1] BOWLES, SAMUEL, AND HENRY LEVIN, "The Determinants of Scholastic Achievement—An Appraisal of Some Recent Evidence," *J. Human Resources* 3:5–24, Winter 1968.

[2] ———, "More on Multicollinearity and the Effectiveness of Schools," *J. Human Resources* 3:393–400, Summer 1968.

[3] CHOW, GREGORY C., "Tests of Equality Between Sets of Coefficients," *Econometrica* 28:591–605, July 1960.

[4] COHN, ELCHANAN, "Economies of Scale in Iowa High School Operations," *J. Human Resources* 3:423–434, Fall 1968.

[5] CRONBACK, LEO J., *Essentials of Psychological Testing*, New York, Harper and Brothers, 1960.

[6] DECACCO, JOHN P., *The Psychology of Learning and Instruction: Educational Psychology*, Englewood Cliffs, New Jersey, Prentice Hall, 1968.

[7] GREEN, ROBERT L., AND WILLIAM W. FARQUHAR, "Negro Academic Motivation and Scholastic Achievement," *J. Educational Psychology* 10:241–43, Oct. 1965.

[8] HANSON, NELS W., "The Size Cost Relationship in Public Schools," Trends in Financing Public Education, *Proceedings of the 8th Annual Conference on School Finance*, Chicago, National Education Association, April 1965.

[9] KIESLING, H. J., "Measuring a Local Government Service: A Study of School Districts in New York State," *Rev. Econ. & Stat.* 49:356–67, Aug. 1967.

[10] ———, "The Relationship of School Inputs and Community Characteristics to Public School Performance," Dept. of Econ., Indiana University, Bloomington, 1970, mimeo.

[11] NIXON, RICHARD M., *Message from the President of the United States on Educational Reform*, March 3, 1970, House of Representatives Document 91-267, Washington, U. S. Government Printing Office, 1970.

[12] RAYMOND, RICHARD, "Determinants of the Quality of Primary and Secondary Education in West Virginia," *J. Human Resources* 3:450–470, Fall 1968.

[13] REMMERS, HERMANN, *Introduction of Opinion and Attitudes Measurement*, New York, Harper and Brothers, 1954.

[14] RIEW, JOHN, "Economies of Scale in High School Operations," *Rev. Econ. & Stat.* 4:280–87, Aug. 1966.

Communications

THE AGRIBUSINESS SECTOR—AN IMPORTANT LINK IN ECONOMIC GROWTH MODELS

A major difficulty with the application of existing two- and three-sector growth models is that they do not identify clearly enough the main sectors that interact in the process of economic transformation. In two-sector models, economic activity is divided into *agriculture* and *industry*. Three-sector models add *services* as a sector. With these models emphasis is upon the relationship between agriculture and industry in the process of economic development. But in that process a part of agriculture moves, unnoticed, into the nonagriculture sector as agribusiness.

This note discusses the usefulness of a growth model that would include agribusiness as a sector. Attention is given to the importance of agribusiness as a growth sector in developing countries; the relationships between farming and agribusiness; and some of the data problems involved in constructing a model.

The proposed model would identify on-farm production and processing activities as a *farming sector*; off-farm activities related to farm inputs, processing, storing, and handling farm products as an *agribusiness sector*; and *nonagriculture* as a third sector. The model would be used to reveal the interactions between technological change in farming and the growth of off-farm activities essential to modern agriculture, in order to identify areas in an economy where intervention or assistance could be applied to promote economic development.

Agribusiness Growth and Economic Development

Industries for processing and handling farm products usually are among the first important industrial activities to emerge in the modern or semimodern sector of a developing economy. The importance of these activities at early and later development stages in selected countries is shown in Table 1 as reported in [5, pp. 91 ff.]. Even though the relative importance of the agriculture-based industries declines with development, they continue to be important.

Agriculture-based industries have strong linkages with other sectors of the economy. An ECAFE study [4] reported that the total demand effect resulting from increased demands for agricultural processing and textile products was greater than for any other manufacturing sector. These intersector linkages add to the value of separate identification of the agribusiness sector.

An indication of the growing importance of post-farm agribusiness activity with economic development is provided by changes in the margin between farmers' receipts and consumer spending for food. In the United States the farmers' share of retail value of food has declined from 50 percent in 1947–49 to 39 percent in 1970 [12, pp. 6, 10, and 471]. A study of Indian market areas reported that in 1949–50, producers received 80 to 90 percent of the retail price of maize [7, p. 333]. The ratio between the cost of purchased inputs and the value of farm production also tends to rise during development. In the United States, the value of major purchased inputs was 17 percent of farm income in 1948 and 28 percent in 1970 [10, pp. 489–491]. In India the value of major purchased inputs was reported to be only 2.5 percent of the value of farm production in 1964 [6, p. 20].

The relationship between economic development and changes in the farming and agribusiness sectors has been explored for several countries by Simantov [8], who states the following three principles:

1. Among countries, the value added by farm production as a share of Gross Domestic Product is inversely correlated with the level of GDP per capita. Over time, the share going to farmers tends to decline for all countries.

Table 1. Share of manufacturing output from agriculture-related industries at early and later stages of development, selected countries and areas

Country or area	Early Period		Late Period	
	Date	Share of all mfg.	Date	Share of all mfg.
		percent		percent
United States	1879	57	1960's	30
Canada	1925	61	1961	46
Italy	late 1800's	75	1961–1964	30
Sweden	1896–1900	58	1959–1960	30
Australia	1934–1935	55	1961–1962	31
E. & S. E. Asia	1948	74	1958	67

Source: Adapted from [5, pp. 91 ff.].

2. Off-farm inputs as a proportion of all farm production inputs rise as economic development proceeds. But off-farm inputs tend to remain a stable percentage of GDP. For the countries studied, this ratio centered around 2.5 to 3.5 percent of GDP.

3. The trend in margin of consumer expenditures for farm products over farmers' costs (including purchased inputs) also tends to be similar among countries at the same stage of development and to remain a constant percentage of GDP. For the countries studied, this margin was clustered around 8 or 9 percent of GDP.

A study by Dovring suggests that the Simantov percentages apply reasonably well to growth of the agribusiness sector in many countries except at high income levels [2, p. 3].

A few studies have been made of the magnitude of the agribusiness sector in the United States in terms of labor requirements. In an early study Davis and Goldberg [1] examined the whole process of producing, handling, and distributing agricultural products, including the production of inputs and the marketing of farm products. They also made allowance for secondary and tertiary labor requirements, including, for example, the labor that went into mining of iron and coal that went into the production of farm tractors. As derived by Davis and Goldberg, workers on farms were only 17 percent of the U. S. labor force in 1947, but about 40 percent of the labor force was employed directly or indirectly, in total or in part, in agriculture and agribusiness.

Other studies of employment in agribusiness in the United States give lower figures for off-farm employment. Dovring and Gossling [3, p. 12] estimated the full-time man-equivalent labor required for off-farm production and servicing of farm inputs was about two million man-years in 1965. With respect to labor used in marketing, the U. S. Department of Agriculture estimates that the number of persons on a full-time equivalent basis who were engaged in marketing farm foods for U. S.-civilian consumers was 5.3 million in 1970 including 1.3 million in manufacturing, 0.6 million in wholesaling and assembling, 1.5 million in retail stores, and 1.9 million in restaurants and other eating places [11]. Workers on nonfood products and on production for export are not included. The Dovring and USDA estimates indicate that total number of United States workers employed in agribusiness is considerably more than twice the approximately 2.7 million man-equivalent workers on farms, assuming 2,400 hours per worker [10, p. 492].

The Proposed Three-Sector Model

The proposed model includes sectors of Farming, Agribusiness, and All Others.

The Farming Sector would include:

1. Farm-related activities of farmers including work on other farms.
2. Inputs of family and hired labor.

The principal components of Agribusiness would be:

1. Production, distribution and application of inputs of nonfarm origin, including those made by landlords, and the nonfarm portion of feed and seed inputs. Construction of farm structures and land improvements when not done by farmers.
2. Credit services to farmers.
3. Marketing and processing of farm products.
4. Off-farm storage.
5. Transportation of farm products.
6. Advisory, grading, and regulatory services.

The third sector would include all other economic activities. It would probably be necessary to include here some inputs related to farm production, such as general education, road building, and communications, because of the problem of allocating a share to agriculture. The third sector might also contain activities remotely related to farm and agribusiness production. For example, farm equipment manufacture would be part of agribusiness, but production of the coal used in the manufacture of farm equipment might be considered nonagriculture. Inclusion in agribusiness of such derived demands for production resources could add to the problems of estimation without contributing much to the value of the model. The main need is to identify the manpower, investment, and managerial requirements, and the outputs of the various specific agribusiness industries.

The proposed model would not serve all purposes and would not replace present two- and three-sector models. But it would be especially useful for study of the agricultural development process, permitting examination of interactions between the farm and off-farm sectors of the food and fiber industry and the relations of these two sectors to the rest of the economy.

Data Problems of an Agribusiness Sector

Preparation of estimates for an agribusiness sector would pose substantial, but not insuperable definitional and data problems. For countries that have income or production data on the basis of the International Standard Industrial Classification, several agribusiness industries can be identified directly. Others would require estimation of the fraction related to agriculture.

The United Nations Department of Economic and Social Affairs publishes data on employment and value of output on an industry basis for 69 countries [9, Vol. I]. Information is available for each year since 1957 and for some countries since 1953, according to ISIC codes for 20 industry groups that would permit identification of the following important agribusiness related activities: food products (meats, dairy, and preserved fruits and vegetables); beverages; tobacco; textiles; footwear, wearing apparel, etc.; and leather and leather and fur products.

The United Nations also publishes quantitative production data for 315 industrial commodities for 67 countries [9, Vol. II]. There are separate categories, according to ISIC codes, for most of the important processed agricultural commodities; fats and oils, animal feeds, fertilizers, specified farm implements, and specified processing equipment. United Nations statistics cover only industries, not services.

Countries that have good input-output data offer the best opportunities to develop the proposed three-sector model and to analyze the linkages and complementarities among sectors and sub-sectors. Some work along this line has been done for India by Hendrix and Giri, using the 62-sector input-output tables for 1964–65 [6, Chs. 4 & 5]. The work of Davis and Goldberg [1] is still worth consulting for examples of the procedures involved in estimating the fractions of various industries and services related to agriculture.

Summary and Conclusions

Models of rural-urban transformation for developing countries are inadequate to explain and quantify processes by which food and fiber production and distribution are transmuted from primitive and largely self-sufficing activities into a purchased input-farm production-commercial distribution complex. Oversimplified models obscure the process by identifying agriculture only with on-farm activities. If misinterpreted, they can exaggerate the labor displacement effects of farm mechanization, understate agriculture and agribusiness's share of national income and employment, and obscure the dynamic and rapidly growing farm input, processing, and distribution activities. These models are of limited help to planners in identifying and assigning priorities to sector needs for resources, investment, and training.

The proposed model would include sectors for (a) farming, (b) agribusiness, and (c) all other. Inclusion of agribusiness as a sector would shed light on the growth of the system of services and inputs associated with farm technological advance, and the linkages, complementarities, and substitutions among the various components. The model would furnish an improved basis for the application of systems analysis to development planning and would also be helpful in showing the importance of agribusiness as a creator of jobs and income in early stages of economic growth. Data requirements for separate identification of an agribusiness sector would be difficult, but much data are available or can be derived from United Nations statistics, augmented in a few countries by input-output tables.

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References

[1] DAVIS, JOHN, AND RAY GOLDBERG, *A Concept of Agribusiness*, Cambridge, Harvard University Press, 1957.

[2] DOVRING, FOLKE, *Income Growth Rate and Sector Proportions: The Share of Agriculture at Successive Levels of Income*, Dept. of Agr. Econ. AERR-97, University of Illinois, 1968.

[3] ———, *Productivity of Labor in Agricultural Production*, Illinois Agr. Exp. Sta. Bull. 726, 1967.

[4] ECAFE, *Economic Survey, Part I*, Bangkok, Economic Commission for Asia and the Far East, 1965.

[5] FAO, "Agriculture and Industrialization," *The State of Food and Agriculture, 1966*, Rome, 1966.

[6] HENDRICKS, W. E., AND R. GIRI, *India's Agricultural Progress in the 1950's and 1960's*, New Delhi, Directorate of Economics and Statistics, Ministry of Food, Agriculture, Community Development and Cooperation, 1970.

[7] MELLOR, JOHN, *The Economics of Agricultural Development*, Ithaca, Cornell University Press, 1967.

[8] SIMANTOV, A. "The Dynamics of Growth and Agriculture," *Zeitschrift für Nationalekonomie.* 27:328–351, Sept. 1967.
[9] United Nations, Department of Economic and Social Affairs, *The Growth of World Industry,* New York, 1970.
[10] U. S. Department of Agriculture, *Agricultural Statistics, 1971,* 1971.
[11] ———, Economic Research Service, Letter from J. C. M. Finley (unpublished), October, 1971.
[12] ———, *The Marketing and Transportation Situation,* August, 1966.

MECHANIZATION AND THE DIVISION OF LABOR IN AGRICULTURE

American agricultural technology is dependent upon an abundance of cheap energy. An energy crisis in the future or even a substantial rise in the price of energy will require that agriculture undergo a drastic reorganization. This paper investigates the nature and degree of agriculture's dependency on cheap energy with the hope that it will lead others to think about what an energy crisis would mean for agriculture.

"Cheap Energy" as a Source of Productivity

Until the harnessing of fossil fuels on the farm, most increases in the productivity of agricultural labor could be explained by increases in capital, labor, and land. With the advent of the tractor on the farm, productivity rose faster than capital [23]. In fact, productivity rose much faster than in industry [4, 6, 15].[1] Much of this increase in productivity can be attributed to increases in purchased farm inputs [19].

As late as 1920, more than 20 million horsepower was provided by horses and mules that had to be fed from the land [11, p. 21]. Not only was land freed by the coming of the tractor, labor was also freed because one man plowing with a tractor could do the work of several men plowing with mules. Replacement of human energy by mechanical power is shown in Table 1.

Another advantage of mechanization is related to the division of labor in agriculture. Earlier economists were not very optimistic about improvements in agricultural productivity since they believed that it depended upon the division of labor and that there was not much scope for improvement in the division of labor in the farm. This point was made twice by Adam Smith [22, pp. 6, 641] and was echoed by John Stuart Mill:

> Agriculture . . . is not susceptible of so great a division of occupations as many branches of manufacturers, because its different operations cannot possibly be simultaneous. One man cannot always be ploughing, another sowing, and another reaping. A workman who only practiced one agricultural operation would lie idle eleven months of the year. The same person may perform them all in succession, and have, in most climates, a considerable amount of unoccupied time. [20, pp. 131–132; see also 1]

Alfred Marshall also accepted the difficulty of the industrialization of agriculture which he said "cannot move fast in the direction of the methods of manufacturing" [18, p. 209].

But in fact, agriculture did move quite fast in the direction of manufacturing since the mechanization of agriculture meant that many jobs were transferred from the farm to the factory. For instance, the growing of hay for horses was replaced by the refining of petroleum for tractors. Workers displaced by the new machines migrated to the city where many of them were employed in producing machines and other nonfarm inputs for their comrades who remained on the farm. Between 1919 and the present, U. S. industries have employed almost 2 million man-years per annum in the production of goods and services used in American agriculture [9, p. 13].

Table 1. How mechanical power replaces human power

Year	Tractor Horsepower Millions	Cost of Operating and Maintaining Farm Capital Million Dollars	Man Hours of Farm Work on Crops Millions
1920	5		13,406
1950	93	5,640	6,922
1960	154	8,310	4,590
1969	204	11,500	3,431

Source: [25].

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[1] Farm productivity may now be leveling off. The USDA Index of Agricultural Productivity stood at 83 in 1955. During the next five years it rose to 96 and by 1965 had reached 101. Between 1965 and 1970 it fell to 99 [24, p. 164].

Energy Use in Agriculture

To show what high levels of energy consumption mean for agriculture, Fred Cottrell compared the energy budgets of Japanese and American farming [7]. He found comparable statistics for two rice farms—one in Japan and the other in Arkansas. Each had approximately the same yield per acre. In Japan an acre could be cultivated and harvested with about 90 man-days—equivalent to 90 horsepower hours. On the Arkansas farm, more than 1,000 horsepower hours of energy were used just to power the tractor and truck. Moreover, the nonresidential consumption of electrical energy exceeded 600 hp-hours. Cottrell did not even include the energy required to produce the tractors and equipment. On a national level, U. S. farmers burned about 7 billion gallons of motor fuel according to 1965 statistics [26].

The fertilizer industry consumes enormous amounts of energy. Current technology requires about 10^7 calories for each kilogram of nitrogen fertilizer produced commercially [8, p. 204]. In 1969 United States farms consumed about 7.5 million tons of nitrogen fertilizer which required about 2×10^{14} BTU's, which is equivalent in heat value to more than 1.5 billion gallons of gasoline or about 8 gallons for each American [24, p. 571]. But nitrogen fertilizer makes up only one fifth of our total commercial fertilizer supply [24, p. 570]. A. B. Makhijani [16] estimates that the overall average energy use in the fertilizer industry is a little less than 2×10^7 BTU's per ton of fertilizer. Since the total 1969 fertilizer usage was about 40 million tons, Makhijani's figures represent a total of about 8×10^{14} BTU's or a heat equivalent of more than 30 gallons of gasoline for every American.

Energy costs for the production of farm implements amount to 4 gallons of petroleum for every American, not counting the energy costs of supporting industries [17].

Electricity also contributes greatly to farm production. In 1970 U. S. farms consumed more than 50 trillion BTU's of electrical energy [13]. However, the production of one BTU of electrical energy requires 3.07 BTU's of fuel input [6, p. 8]. Thus farm electrical production actually represents more than 150 trillion BTU's or an equivalent of about 4 gallons of gasoline for every American, not counting the energy used by the supporting industries that supply that industry [17, p. 15].

The energy cost of the food processing sector is also significant. Makhijani estimates that this sector consumes about 10^{15} BTU's or an amount comparable to the consumption of energy by tractors [17, p. 12].

Much of the energy used in the distribution and processing of food should be charged to the organization of agricultural production that has minimized production costs through regional specialization. This specialization requires that food be transported longer distances and also that much food be processed to avoid spoilage in the often circuitous road from farmer to consumer. In 1971 $6 billion was spent for transporting food by rail and inter-city trucks [24, p. 545]. Brown and Pilz estimate that transporting food from farmer to consumer requires an unrealistically low figure of 1 billion gallons by assuming that all products move by rail in fully loaded cars with no empty back hauls.

Even the 1.8 billion gallons of fuel used for heating farm households are an important element of farm efficiency [26]. Previously, "cutting wood absorbed as much if not more time than any single task on the family farm" [12, pp. 37–38].

If efficiency is measured in terms of the conservation of energy, then American agriculture comes out very poorly. Harris [21, p. 262] estimated that Traditional Chinese wet rice agriculture at its best could produce 53.5 BTU's of energy for each BTU of human energy expended in farming it. But this energy came from people who burned rice in their bodies rather than fossil fuel. In the face of an energy crisis, the present system of agriculture could be irrational.

One method of getting a handle on the energy cost of agriculture would be to add the energy cost of operating tractors; the energy cost of producing electricity and farm implements; and the energy cost of the food processing industry. These activities require the equivalent of about 110 gallons of gasoline for every American, or three times the amount of calories consumed at the table in spite of the energy costs excluded from this calculation.[2] For instance, farmers purchase products containing 360 million pounds of rubber, about 7 percent of total United States rubber production, and 6.5 million tons of steel in the form of trucks, farm machinery, and fences [5, p. 20]. Farms consume about one third as much steel as the automotive industry [5, p. 20].

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[2] The average American consumes about 3,000 kilocalories daily, or an average of 4,280,000 BTU's per annum. This amount contains as much heat as a little less than 34 gallons of gasoline. While some reviewers objected to a comparison between human energy and fossil fuel energy, the fact remains that agriculture appears to be a net energy drain.

For each unit of energy the wet rice farmer expends, he can get more than 50 in return; for each unit of fossil fuel energy we expend, farmers get one third in return. On the basis of this crude measure furnished by these two ratios, Chinese wet rice agriculture is more than 150 times as efficient as U. S. agriculture.

Conclusion

Agriculture uses more petroleum than any other single industry [5, p. 20]; yet agriculture is not the only user of energy in our society. In 1970 the United States consumed about 64,000 trillion BTU's of energy. The average American consumes the equivalent of about 2,000 gallons of gasoline per year; for instance, a typical American consumes the energy equivalent of about 10 gallons of gasoline annually just to watch a black and white television set [3, p. 7]. By that standard agriculture's consumption of 100 gallons of gasoline to feed one person does not seem extravagant. Besides, the U. S. uses more than 20 percent of its acreage for exports which feed citizens of other nations, and some of our crops are used for industrial purposes [24, p. 533].

The problem is that agriculture is supposed to be the *energy producing* sector of the economy.[3] Harvested crops capture solar energy and store it as food or some other useful product. Yet the energy captured is small compared to the energy burned in the process. If the world is facing a future with rising energy prices, the highly mechanized technology currently used in the U. S. may be inappropriate.

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[3] Some writers argue that crops have the potential of becoming a major energy source for the economy. Kramer *et al.* points out that corn silage grown as feed costs about $7.30/ton undelivered in 1971 and that the energy stored in this corn is equivalent to that of coal at $12/ton [14]. Of course the cost of corn silage "fuel" could be expected to rise as production increased to the point where the corn harvest could supply a sizable fraction of our energy needs. Besides, fossil fuels are a much more concentrated form of energy which makes their transport simpler. However, as one writer has pointed out, much of the "decline of (harvested) materials before the onslaught of synthetic products in recent years is due to the enormous amount of scientific and technical research that has been carried out to ensure the fullest utilization of petroleum by-products. No comparable effort has been made for plant products..." [10, p. 51].

References

[1] BREWSTER, JOHN M., "The Machine Process in Agriculture and Industry," *J. Farm Econ.* 32:69–81, Feb. 1950.

[2] BROWN, STEPHEN L., AND ULRICH L. PILZ, *U. S. Agriculture: Potential Vulnerabilities*, Stanford, Food Research Institute, Jan. 1969.

[3] BRUNE, W. D., JR., "The Economic Impact of Electric Power Development," paper presented at the National Engineers Week Symposium, Chico State College, Feb. 26, 1972, mimeo.

[4] CHANDLER, CLEVELAND A., "The Relative Contribution of Capital Intensity and Productivity to Changes in Output and Income in the United States Economy, Farm and Non-farm Sectors," *J. Farm Econ.* 44:335–348, May 1962.

[5] U. S. Congress, House of Representatives, Committee on Agriculture, *Food Costs—Farm Prices: A Compilation of Information Relating to Agriculture*, 92nd Cong., 1st sess., July 1, 1971.

[6] COMMONER, BARRY, AND MICHAEL CORR, "Power Consumption and Human Welfare in Industry, Commerce and the Home," to be published in *Electric Power Consumption and Human Welfare, The Social Consequences of the Environmental Effects of Electric Power Use*, eds. Howard Boksenbaum *et al.*, by the American Association for the Advancement of Science, Committee on Environmental Alterations.

[7] COTTRELL, FRED, *Energy and Society*, New York, McGraw-Hill Book Company, Inc., 1955.

[8] DELWICHE, C. C., "Nitrogen and Future Food Requirements," in *Research for the World Food Crisis, A Symposium Presented at the Dallas Meeting of the American Association for the Advancement of Science, December, 1968*, ed. Daniel G. Aldrich, Jr., Publication 92, Washington, D.C., American Association for the Advancement of Science, 1968.

[9] DOVRING, FOLKE, *The Productivity of Labor in Agricultural Production*, Illinois Agr. Exp. Sta. Bull. 726, Sept. 1967.

[10] FORTHOMME, P. A., "Can Rice Replace Petroleum," *Ceres* 1:50–51, Sept.–Oct. 1968.

[11] FOX, AUSTIN, *Demand for Farm Tractors in the United States*, USDA ERS Agr. Econ. Rep. 103, Nov. 1966.

[12] GATES, PAUL W., "Problems in Agricultural History, 1790–1840," *Agr. History* 46:33–58, Jan. 1972.

[13] HIRST, ERIC, National Science Foundation, Environmental Program, Oak Ridge National Laboratory, personal correspondence.

[14] KRAMER, MARC, THOMAS BAKER, AND ROBERT H. WILLIAMS, "Solar Energy," to be published in *Electric Power Consumption and Human Welfare, The Social Consequences of the Environmental Effects of Electric Power Use*, eds. Howard Boksenbaum *et al.*, by the

American Association for the Advancement of Science, Committee on Environmental Alterations.

[15] LAVE, L. B., "Empirical Estimates of Technological Change in United States Agriculture," *J. Farm Econ.* 44:941–952, Nov. 1962.

[16] MAKHIJANI, A. B., personal communication.

[17] ———, AND A. J. LICHTENBERG, *An Assessment of Energy and Materials Utilisation in the U.S.A.*, Electronics Research Laboratory Memorandum ERL-M310, University of California, Berkeley, Sept. 22, 1971.

[18] MARSHALL, ALFRED, *Principles of Economics*, 8th ed., London, Macmillan and Co., 1936.

[19] MEIBURG, CHARLES O., "Nonfarm Inputs as a Source of Agricultural Productivity," *Food Res. Inst. Studies* 3:297–321, Nov. 1962.

[20] MILL, JOHN STUART, *Principles of Political Economy*, ed. W. J. Ashley, London, Macmillan and Co., 1909.

[21] RAPPAPORT, ROY A., *Pigs for the Ancestors*, New Haven, Yale University Press, 1967, p. 262, referring to Marvin Harris, "Cultural Energy," unpublished.

[22] SMITH, ADAM, *An Inquiry into the Nature and Causes of the Wealth of Nations*, New York, Modern Library Cannan edition, 1937.

[23] TWEETEN, LUTHER G., AND FRED H. TYNER, "Toward an Optimal Rate of Technological Change," *J. Farm Econ.* 46:1075–1084, Dec. 1965.

[24] U. S. Department of Agriculture, *Agricultural Statistics, 1972*, Washington, 1972.

[25] ———, *Changes in Farm Production and Efficiency, A Summary Report, 1970*, Statis. Bull. 233, June 1970.

[26] ———, *Structure of Six Farm Input Industries*, 1968.

COMMONALITY, FISHERY RESOURCES, POTENTIAL AND POLICY: COMMENT

Professor O'Rourke in his pioneering paper detailed and explored the relationship between the physical yield of a fishery and the economics of its operation [6]. In particular O'Rourke expressed concern with the implications of policy measures to control and regulate a fishing industry to achieve its long-run economic potential. His analysis and literature review reveals only one avenue to deal with the commonality problems arising, *viz.*, that of resorting to outright and continuing government intervention. This note is aimed at offering one further solution to the regulatory problems posed by O'Rourke. It endeavors to achieve this regulation by relying in large measure on economic forces rather than outright public control. Nonetheless, some governmental intervention may be necessary at the outset in forming the industry into the particular economic configuration that produces these optimal market forces.

Cost Curves and Social Valuation

The fishing industry cost curves deduced as theoretically correct and empirically derived by O'Rourke need further comment.[1] First recall that the *AC* curve for the industry is identical to the long run supply curve (denoted *LRSP*) and is delineated by the loci of the average cost associated with intersections of the long-run marginal cost and the short-run marginal cost as number of firms fluctuates in response to changed industry demand. In Figure 1, with cost curves identical to Figure 5 in [6], the *AC* curve or *LRSP* reflects technological diseconomies over the range shown. With constant factor prices (as assumed here and implicitly in O'Rourke's article), this shape is due solely to the particular production function of the industry. The technological real diseconomies shown are external to the firm but are internal to the fishing industry, and such diseconomies (and/or economies in other

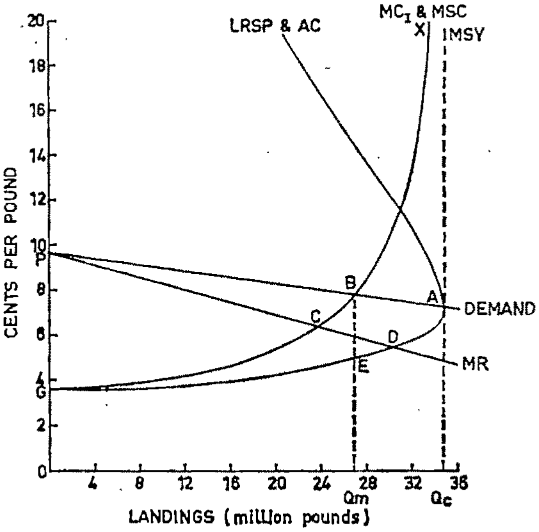

Figure 1. **Average cost, marginal cost, demand and marginal revenue curves, maximum sustainable yield, and social optimum (after O'Rourke)**

cases) "occur when the firms comprising the industry are not able to equalize the ratios of marginal products to factor price ratios which reflect alternative costs, because one or more of the factor costs to the firm do not equal opportunity costs to the industry (or to society). This is often the case, when the technical production function of an industry is not accommodated properly by the prevailing system of ownership, legal rights and the like. Technological diseconomies exist when, in addition to discrepancies between the ratios of marginal products to opportunity costs, the firm's average and marginal cost curves shift upwards as the total demand for some resource rises thus generating a rising industry supply price" [8, pp. 873–874].[2] As O'Rourke notes (for the competitive fishing industry), the *AC* or *LRSP* curve is double-valued exhibiting a backward-bending section. Besides the fishing industry, this phenomenon of a backward-bending supply curve has been observed in other common property resource fields, e.g., multiple-owned oil-fields. In essence, as Worcester [8] so ably illustrates, the absence of a charge on the common property resource, i.e., fishing rights, pushes this freely entered industry to expand to the output where *AC* or *LRSP* equals price and abnormal profits are eliminated. But at this greater than optimal output, Q_c in Figure 1, marginal cost is well above average cost and price; thus a social loss illustrated by the triangle *BXA* is incurred. Fishing effort, i.e., scarce capital and labor, is being wasted. In the absence of a charge on fishing rights the industry has expanded to where the alternative marginal contribution of these resources in other industries exceeds the marginal value product in fishing. O'Rourke notes that equating marginal cost to price is the necessary rule to be followed to ensure an optimal industry output, both economically efficient and with exploitation below maximum sustainable yield. A tax simulating the unpaid resource rent is among the most common possibilities usually canvassed to achieve this end. A difficulty of this approach is that the size of the rent or charge would need to vary as the industry price and optimal output varies. "It will be a charge sufficient to make the private factor cost equal to its social cost" [8, p. 875].

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[1] By far the best explanation combined with an explicit example of the derivation of these curves is given by Worcester [8]. This paper leans heavily on his analysis. Further theoretical refinements with the possibility of interesting policy implications are to be found in Gould [2].

Policy Measures

Governments faced with the situation described above have often resorted to pricing the common fishery resource by a license type of tax on inputs or outputs, or in the extreme, promulgating restrictive regulations designed to reduce the efficiency of fishing effort [4]. A tax on output that reduced the landed price to fishermen to *E* (a point on the *LRSP* curve) in Figure 1, would bring about the required adjustment to an optimal output and number of fishing firms. Nonetheless, besides being unpopular among fishermen and politically unpalatable, the administration of such taxes would be complex in their regulatory role. Adjustments in the case of either type of tax would have to be made as factor costs, product prices, and technology changed, or induced output would be suboptimal. Given these complications, Worcester's suggestion of allowing economic forces to regulate a restructured industry becomes attractive.

The policy measure proposed is to create a simple maximizing monopsony in each independent market area. For income distributional purposes the author suggests the further requirement that this monopsony be formed as a fisherman's cooperative. As illustrated below, if the single buying authority acts as a simple maximizing monopsonist (not a discriminating one), the industry will be regulated to the optimum output and the result is an analogue of charging finely-tuned optimal rents on the fishery resource.

As illustrated in Figure 1, the *AR* or demand curve represents the derived demand curve for the unprocessed landed fish. A maximizing simple monopsonist buys quantity Q_m at price Q_mE and resells at price Q_mB (plus its value added per unit by handling and processing). This output is chosen as it maximizes profit to the processor.[3] Profit is equal to *BE* per unit of production; *BE* is also equivalent to the optimal rent under competition necessary to equate marginal social cost with price. Hence as a result of the simple monopsonist seeking maximum profits, output is induced to an optimal level where MC_I (the marginal social cost) equals price and no welfare loss is incurred. Overfishing is eliminated. Besides being a social optimum, this output is also stable with respect to entry and exit of fishermen from the industry. The optimal price Q_mE paid to the fishermen is on the industry *LRSP*. This means that the correct equilibrium number of fishing firms and stable output is induced by paying this price.

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[2] A further inherent assumption is involved here. The improperly priced factor (in this case fishing rights) must be of use to one industry alone. Otherwise pecuniary externalities and not technological ones would be involved and thus a different analysis required.

[3] As is well known, the simple maximizing monopsonist attempts to equate the marginal revenue product of the factor (shown by the derived demand curve for unprocessed fish in this case) with the marginal cost of the factor to him. The industry marginal cost curve MC_I, which is also the marginal social cost in this case, is the appropiate marginal cost curve of the factor to the monopsonist. In this way the external diseconomy is internalised within the industry.

Informational requirements necessary to monitor the fishery in its restructured framework should not prove an insuperable obstacle. Bell's model of the Northern Lobster Fishery appears of wider applicability, and such approaches promise to provide the requisite decision variables without either overly heavy data or computational burdens [1].

Policy Implications

While the problem of inducing optimum social output (which is of necessity below maximum sustainable yield) is solved in an efficient manner by effecting the industry configuration given above, further desirable properties flow from the basis of the cooperative arrangement. First, unlike the case of multiple processing firms in each market, there is no incentive for the single processing authority to own its own vessels and "run their fishing operations at cost in order to secure adequate supplies of raw materials and . . . be content to make their profits from their processing and merchandising operations" [6, p. 591]. All available output is channeled to the single processor without need for direct control over the fishing operation. There is no tendency to overfishing from any pressure on a processor to compete with other plants for throughput. Whatever profits are available from processing and merchandising are maximized at the optimal output Q_m and are unaffected by ownership of vessels. A discriminating monopsonist, however, e.g., a processing firm conducted by outright private enterprise, has both an incentive to own a portion of the fleet and to promote overfishing. By definition the discriminating monopsonist offers all-or-nothing bargains to each fisherman, or perhaps pays a minimum price for each unit purchased. An economic interpretation of the above behavior is that the discriminating monopsonist's marginal cost curve and his average cost curve are equated. The average cost curve concerned is also the *LRSP* for the industry. The outcome here is that the discriminating monopsonist maximizes profit at suboptimal output Q_c, thus promoting overfishing. The social loss involved is again *BXA*, the same as if no charge (or rent) is attached to the fishery resource.[4]

While the negative aspects of licensing and taxation charges as a means of fishery control have been stressed, one feature of taxation control, the desirable income distribution effects of government spending of tax revenues, has been neglected in the discussion.[5] In this regard the cooperative operation described may go some way to match this desirable feature. Distribution of processing and merchandising profits over the fleet operators would probably meet with approbation by the community. If for any reason the community rejects this distributional feature, a government-owned monopsonist could substitute as processor rather than the cooperative, perhaps with profits spent on industry research, technical education, and or safety and navigational improvements for the fishing fleet.

X-inefficiency and Welfare Loss

Recent literature dealing with industries and firms sheltered from market pressures illustrates the tendency towards the incursion of "slackness," or in economic terms, X-inefficiency [3]. The cooperatively-owned monopsonist could be prone to this phenomenon (as perhaps would be the alternative market set-up of a government-owned plant). Still, private industry is not immune either. It is not unlikely that privately-owned and operated processing firms in a geographically compact market could implicitly agree on market shares and follow "the quiet life."

Nonetheless, if X-inefficiency is experienced in the cooperatively-owned monopsonist's plant, it could cause the derived demand curve for unprocessed fish to shift downwards, thus lowering the economically efficient output level for the fishing industry. At first glance such a move suggests social loss. Parish and Ng [7] have ably demonstrated that this X-inefficiency incursion need cause no social loss.[6] The key question to ask is, "who bears the cost of this substitution of leisure for money income?" If the board of management and shareholding of the cooperative is comprised of the fleet operators, and this board allows the degree of X-inefficiency noted to erode their processing profits, there is no social loss from this "slackness." All that is happening is that the extra effort necessary to "get the most out of" its resources is judged as not worth the reduction of leisure (or perhaps the difficulties involved in disciplining workers, etc., is considered as too unpleasant). Fishermen in their joint role as board of management and shareholders could by further effort eliminate the X-inefficiency noted, but it is their decision to put up with the consequences. The "quiet life" appeals more than the extra income. Hence, no social waste is incurred, although a redistribution of income from consumers to processors and some factor suppliers is involved.

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[4] A possible example of this type of operation leading to social loss is the present organization of shrimp catching and processing in the recently opened Gulf of Carpentaria Fishery in Northern Australia. Problems associated with fisheries regulation in this setting are outlined in [5].

[5] However, in the case where fishery control is exercised by auctioning rights to take a limited number of fish, perverse income distributional effects may be experienced. Poorer sections of the fishing community could be excluded. If the revenue raised was spent specifically on such items as industry research, or navigational aids, little benefit would flow to those disadvantaged. Such problems are outlined by North and Miller [4].

Summary

(1) Owing to the commonality of the fishery resource, the long-run economic potential of a fishery is jeopardized under a *laissez-faire* policy approach.

(2) Government intervention to regulate fishery output to the optimum social output via taxation on inputs or outputs runs into complex administrative and technical problems.

(3) It is possible to simulate the optimal charge (or rent) on the fishery resource that will bring about the optimal social output, by structuring the industry so that each market is served by a simple maximizing monopsonist as single processor.

(4) Organization of the ownership of each simple maximizing monopsony as a fisherman's cooperative has desirable income distributional features. These features combined with the minimal need for technical regulation to provide the optimal social output would be especially desirable in the lower income, less-developed countries.

(5) A cooperative enterprise should be easier to implement politically than outright and continuing government intervention and thus is deemed more desirable on this count.

(6) With the cooperative organization, where profits are channeled back to the fishermen, there is no tendency for the processing arm of the cooperative to act as a discriminating monopsonist and encourage overfishing.

(7) Further advantages accrue to the cooperative enterprise in that no social loss need be experienced due to the incursion of X-inefficiency in the processing operation. Should X-inefficiency flourish, those that allow this "slackness" bear its cost in money income foregone.

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[6] For a full theoretical treatment, the reader is referred to [7, Section V]. Parish and Ng's exposition is best viewed through a model of the processed product market, not the factor market, as presented in Figure 1.

References

[1] BELL, F. W., "Technological Externalities and Common Property Resources: An Empirical Study of the U.S. Northern Lobster Fishery," *J. Pol. Econ.* 80:148–158, Feb. 1972.

[2] GOULD, J. R., "Externalities, Factor Proportions and the Level of Exploitation of Free Access Resources," *Economica* 39:383–402, Nov. 1972.

[3] LEIBENSTEIN, H., "Comment on the Nature of X-Efficiency," *Quart. J. Econ.* 86:327–331, May 1972.

[4] NORTH, D. C., AND R. L. MILLER, "The Economics of Nonownership: The Bristol Bay Salmon Fishery," in *The Economics of Public Issues*, New York, Harper and Row, 1971.

[5] "Orderly Development of Northern Fisheries Aim of Legislation," *Australian Fisheries Newsletter*, 27:35, Jan. 1968.

[6] O'ROURKE, D., "Economic Potential of the California Trawl Fishery," *Am. J. Agr. Econ.* 53:583–592, Nov. 1971.

[7] PARISH, R., AND Y. K. NG, "Monopoly, X-inefficiency and the Measurement of Welfare Loss," *Economica* 39:301–308, Aug. 1972.

[8] WORCESTER, D. A., JR., "Pecuniary and Technological Externality, Factor Rents, and Social Costs," *Am. Econ. Rev.* 54:873–885, Dec. 1969.

COMMONALITY, FISHERY RESOURCES, POTENTIAL AND POLICY: REPLY

I will comment on the extent to which Dr. Cassidy's comment is justified, correct, practical, and sufficient.

I did not, as Dr. Cassidy suggests, intend to imply that commonality problems can be treated only by "resorting to outright and continuing government intervention." My original article suggested how the economic optimum for a fishery might be determined without detailed biological and environmental data and given adequate cost data. In a brief comment on how a fishery might be induced to produce at that economic optimum, I cited Crutchfield and Bell, both of whom supported my view that reduction of excess resources used in a fishery is "unlikely to come about without public control" [5, p. 591]. I failed to make sufficiently clear the distinct problems of terminating suboptimal conditions in a fishery and subsequently managing that fishery at the economic optimum.

I would not rule out the possibility of conditions arising under which a fishery would voluntarily seek to regulate itself at the economic optimum, although, like Cassidy, I see that as unlikely. Given the existence of a regulatory agency, Cassidy would favor reliance "in large measure on economic forces." Crutchfield uses slightly different wording, but his import is similar: "Ideally, then, regulation should seek, as far as possible to establish conditions under which the profit motive works with, rather than against, sound management of the resource" [2, pp. 26–27].

Accordingly, I am in complete sympathy with the rationale for Cassidy's choice of a regulatory policy. In addition, the simple maximizing monopsonist solution does achieve the goal of equating marginal social cost with price so that both the fishery and society are at an economic optimum. However, I am not sure that the X-inefficiency argument adds measurably to Cassidy's policy proposal. First, it is only true that X-inefficiency need cause no social loss under specific assumptions and conditions.

Second, X-inefficiency is likely to lead to failure of the monopsonist to plough back sufficient resources into the biological and economic research and technological development needed to guide the fishery in a dynamic environment.

Third, in a fishery, inefficiency in terms of a reduction in quality standards, irregularity of supply, etc., is as likely to result from monopsony as is any type of X-inefficiency. Social and redistributional effects of such inefficiencies are unpredictable without knowledge of the utility mappings of consumers.

Is the Cassidy proposal practical? The core of his proposal is the setting up of a simple maximizing monopsony in each independent market area. How can we ensure that the agency will behave as a simple maximizing monopsonist, for example, that in practice it will not become a discriminating monopsonist for the benefit of the board of directors? Perhaps, more critically, where the monopsonist also acts as sole processor, economies of scale in processing and elastic demand may lead the processor to prefer an output greater than Q_m in its processing operation. The combined monopsonist-processor will choose the output Q_m only by chance. Finally, I am not convinced that the existing firms with fishing and processing operations would consider the simple maximizing monopsonist solution politically palatable.

However, my most serious reservation about the Cassidy proposal and about the types of solutions suggested by Worcester is whether they provide a sufficient answer to real-world issues. For example, commonality may have given rise to chronic problems in fisheries, but fixing output at an optimum level will not eliminate these problems. Fisheries have been subject to the danger of overfishing, but also to underemployment, low income, lagging technology, inferior training of participants, and a difficulty in recruiting qualified replacements. In California the commercial fisheries are particularly under siege from sports fishing interests for the fishery resource; from pleasure boats, freight ships, and oil drilling rigs for the ocean right-of-way; and from real estate, tourism, and other interests for the shoreline and its facilities [4].

How the problem of the California fishery is defined depends on who is doing the defining—the Eureka chamber of commerce, the California legislature, the U. S. federal government, or interstate or intergovernment commissions. If regulation is to be introduced, the goals of regulation must be specified in terms of the relevant authority. For example, Crutchfield's analysis of the Pacific halibut fishery led him to suggest that the performance of management of that fishery should be judged in terms of output and factor allocation, efficiency, progressiveness, income distribution, and stability [2, p. 24]. Noneconomists (the majority of citizens) might specify alternative or additional goals.

Implementation of each policy will require specification and assembly of the data needed to make that policy operative. Data may be more of a problem than my original article or Cassidy's comment might suggest. The analysis of costs underlying my Figure 5 uses "number of vessels" as a proxy for "effort." Units of effort are assumed homogenous. Of course effort is a joint product of vessels of different age, capacity, and range, and crews of different skill and work-leisure preference, etc. It is difficult to predict, therefore, how different capital-labor combinations might react to different economic forces. If a simple maximizing monopsonist specified that it would buy quantity Q_m at price Q_mE, would that lead to an intensified race for early season output, a shorter season, no reduction in vessel numbers, and a continuation of low returns to capital and labor? Evidence from agriculture suggests that such undesirable consequences would follow.

The concept of asset fixity seems particularly applicable to the likely reaction in a fishery. Of all U. S. fishing vessels licensed in 1969, 50.2 percent were over 20 years old; the comparable figure for the Pacific Coast was 63.6 percent [3]. Fishermen, like small farmers, are frequently older and trained only in their own occupation with no alternative skills. Tweeten's analysis for farm labor fixity can be applied directly to fishery labor [6]. There are really four prices relevant to the entry, stay put, or exit of fishery labor—the price needed to attract labor into a fishery, the opportunity price, the transfer price (opportunity price less transfer costs), and the reservation price below which fishermen who value their way of life highly will leave the fishery. A policy to encourage movement of fishermen out of the industry may require measures to improve the opportunity price or reduce the transfer cost.

Analysis for fishing vessels may be more complex in that fixed costs such as provision for depreciation, interest on capital, and return to management are frequently ignored in decision-making. Given the longevity of a fishing vessel, such costs can be ignored without visible penalty for many years. Asset fixity of both labor and vessels may thwart normal economic response to market forces.

The theory of asset fixity is an attempt to explain a dynamic phenomenon in a static, deterministic framework. As Carlson points out, "In the end, a deterministic model must be replaced by a stochastic model, especially if a rational fishery management policy is to be imposed upon the community. Let us say that the conception of goals for which fishery management must work will come from a clear understanding of a deterministic model, but implementation will have to take place within a stochastic model" [1, p. 1].

We are still a long way from being in a position to recommend fishery management solutions even where the problems of a fishery are adequately defined and the goals of management are unambiguously specified. Meantime, there is much we as economists can do to measure empirically how the resources used in various fisheries actually respond to economic and other forces, and in that light develop and evaluate beneficial management policies.

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References

[1] CARLSON, ERNEST W., *Bio-Economic Model of a Fishery*, Working Paper 12, Washington, U. S. Bureau of Commercial Fisheries, March 1969.

[2] CRUTCHFIELD, JAMES A., AND ARNOLD ZELLNER, *Economic Aspects of the Pacific Halibut Fishery*, Fishery Industrial Research, Vol. 1, No. 1, Washington, U. S. Bureau of Commercial Fisheries, 1963.

[3] LYLES, CHARLES H., *Fishery Statistics of the United States, 1969*, Washington, U. S. Bureau of Commercial Fisheries, 1971.

[4] O'ROURKE, A. D., AND D. B. DELOACH, *The California Fresh and Frozen Fishery Trade*, California Agr. Exp. Sta. Bull. 850, 1971.

[5] O'ROURKE, DESMOND, "Economic Potential of the California Trawl Fishery," *Am. J. Agr. Econ.* 53:583–592, Nov. 1971.

[6] TWEETEN, LUTHER, *Foundations of Farm Policy*, Lincoln, University of Nebraska Press, 1970.

Reviews are listed alphabetically by authors.

Book Reviews

Avramovic, Dragoslav, coordinating author, *Economic Growth of Colombia: Problems and Prospects*, Baltimore, The Johns Hopkins University Press for the International Bank for Reconstruction and Development, 1972, xx + 509 pp. ($15.00)

This is an important volume, not only for the information it provides—in a handily available form—on the situation and trends of the Colombian economy, but also because it signals the Bank's decision to publish a selection of its major mission reports in the future. These volumes will be of very considerable value to persons not normally having access to the Bank's reports, and feedback may also be useful to the Bank. The volume is, in general, well written, well organized, and useful. The presentation is straightforward and more descriptive than analytical.

The first chapter summarizes key features of the Colombian economy and its recent development; subsequent chapters discuss the development of various sectors or focus on specific problems like unemployment and foreign indebtedness. Several chapters discuss industry and agriculture, part of the discussion at the sectoral level and part dealing with industries or crops (coffee) of particular importance or topicality. The Bank's long experience, especially in such sectors as transportation, water, and power, shows in the well informed presentations and accurate information. While less authoritative, the discussions of sectors like agriculture and industry are careful and intelligent ones.

It is natural, given that its function is not a research one, that the Bank's interpretations of most economic phenomena tend to be "'standard" ones. Accordingly, this volume does not present new ways of looking at issues, or new empirical analysis, but rather an up-dated look at the economy's progress in terms of a widely accepted framework. The World Bank's model, built up over years of experience in dealing with developing countries, focuses on three key factors critical in maintaining an accelerated growth rate: "a high rate of savings, a rapid expansion of exports, and a high level of capital inflow" (p. 29). The obvious oversimplification implicit in such a model cannot seriously be criticized, since the Bank's needs are practical, and there is no evidence to gainsay the special role attributed in the model to the three factors just cited.

In discussing the unemployment issue, the mission borrowed liberally from the recent I.L.O. study. While it seems clear that the I.L.O's unemployment theory (summarized on pages 33–34) will require substantial complication and amplification before it can adequately represent the Colombian reality, at the time of the mission it was the most complete study available on the issue. The Bank, no doubt, will take into account new information and interpretations as they come along. Where, as with the unemployment issue, the mission relied on secondary sources, the discussion does tend nevertheless to reflect competent judgment, with useful summary versions of some primary studies being presented.

Occasionally doubtful interpretations show up, reflecting lack of familiarity with detailed information, as where it is reported with respect to coffee farms that the "average size is shrinking because of population pressure" (p. 259). While this conclusion may turn out to be valid, it can hardly be stated as fact at this point, since the two surveys on which it is based are in a number of ways noncomparable.

In places, tautological "'growth accounting" seems to dominate the discussion and masquerade as analysis of cause and effect; it is a useful descriptive device, but sometimes the terminology of causation slips in, as on page 40. "'Turning to the demand side of the labor market, two dominant factors retarded the creation of jobs in Colombia in the post-war period: slow economic growth, particularly in the agricultural sector, and rising labour productivity . . . ." And the ICOR concept and language, a practical one to summarize situations and to provide a first step toward an analysis, can contribute to an oversimplified view of a system. Such tendencies could be criticized were this volume designed to be an in-depth analytical study of the mechanisms involved in the Colombian development process, but cannot be construed as serious faults given its more descriptive purpose, reflecting the mission's objective—the evaluation of Colombia's economic status within the Bank's framework, not an attempt to broaden, narrow, or modify that framework.

To recapitulate, this is a very useful volume to have in print and is a reflection of the work of a clearly competent mission.

R. A. BERRY
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Bard, Robert L., *Food Aid and International Agricultural Trade,* Lexington, D. C. Heath and Co., 1972, xviii + 321 pp. ($12.50)

This book, subtitled "A Study in Legal and Administrative Control," principally discusses the operation of Public Law 480, the FAO Principles of Surplus Disposal, the Committee on Surplus Disposal. It gives less attention to the FAO World Food Program and the EEC food aid policies, because the volumes are smaller and the experience more limited.

Bard teaches international law at the University of Connecticut, has done graduate work in economics, and worked five years with the Agency for International Development. He has requisite qualifications and experience for such a book.

The book has three main parts plus a Concluding Chapter. Part I presents the "Nature, Potential and Threat of Food Aid," three chapters. Part II discusses the "'National and International Legal Framework for Food Aid Transactions," three chapters. Part III identifies the "Techniques of Food Aid Control," four chapters.

The author's attitude is expressed in the final chapter:

> The potential utility of food aid as a supplement to more conventional forms of foreign aid has been accepted by both the aid-giving agencies and academic critics. During the early sixties, food aid was severely criticized as a selfish device of the United States to rid itself of politically embarassing stockpiles. . . . It is now conceded that properly conceived and administered food aid programs can be made consistent with the overall development needs of the recipient and that although any effective food aid program must have some adverse impact upon the commercial agricultural trade interests of developed and developing countries, these can be reduced to acceptable levels. (p. 285)

The author deals in considerable detail with administrative procedures and international discussions to protect the commercial trade of the donor and/or third country exporters. He gives attention to usual marketing requirements, decisions on the volume of food aid, tied or untied sales, additionality, and similar problems of control. One of his unique contributions consists of the discussion of these activities as the beginning of a corpus of international law and evolving common law practices, with the FAO principles of surplus disposal as a starting point.

The book goes into substantial detail on administrative practices, often somewhat defensively of the United States. He does argue that the U. S. has been much more sensitive to the concerns of other exporters than have the EEC nations and in particular, France. Each chapter contains voluminous notes on sources of data, information, and references. A weakness, however, is that the index is fairly casual and does not facilitate returning to the discussion of country problems or particular techniques. Only a handful of the authors cited appear in the index.

A major omission is the lack of any discussion of the impact of food aid upon commercial farmers in the recipient country, or even of the impact upon prices within the country. Since Bard deals in some repetitive detail with the impact on trade of actual and potential competing exporters, the same number of pages would have permitted some attention to the impact within recipient countries. As it is, the reader must somehow accept on faith that the efforts to impose a large measure of additionality will also foster economic development. Bard does recognize that virtually every food aid agreement has had some effect in reducing foreign exchange expenditures over what they otherwise would have been; additionality is never complete.

A less serious omission is the absence of any reference to the uses of local currency, either by U. S. agencies or by local governments.

This is a book for the person with a special interest in food aid. It provides much detail on government operations in implementing P.L. 480 and the counterpart activities in other countries, material not usually publicly available. And the author demonstrates again that P.L. 480 is one of the most complex of the U. S. programs.

LAWRENCE W. WITT
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Bloom, Gordon F., *Productivity in the Food Industry: Problems and Potential,* Cambridge, The MIT Press, 1972, xiii + 314 pp. ($10.00)

This book provides an interesting and detailed look at the opportunities for increased productivity in the food industry. The degree of specificity on techniques will be interesting to manufacturers, wholesalers, and retailers, and suggestions on research opportunities and recommendations for changes in the organization of marketing firms will be interesting to researchers and policy makers.

The objective of the book is, in the words of the author, "to highlight some of the key areas in which major breakthroughs in productivity improvement can be achieved through proper governmental support and industry cooperation" (p. xii). This the author does by describing in detail improved techniques of handling and transporting merchandise, scheduling of truck deliveries, standardization of package sizes, and use of a universal product code to permit optical scanning checkout systems. The underlying theme of the book is that most of these techniques require vertical and horizontal coordination among firms in the industry. Such coordination can be obtained, the author suggests, by voluntary coordination among large firms, through industry groups, through government sponsorship of activities, and through a relaxation of antitrust enforcement.

The first chapter discusses the problem in terms of social goals and the role of productivity in the economy. The author discusses various causes for declining productivity in industry, including wage rates, decreased importance of the work ethic, changing goals of management, and governmental restrictions. Chapter 1 also discusses the limitations of current measures of national productivity and suggests as an alternative a measure called "Total Factor Productivity"—gross output net of purchases of intermediate products and services, divided by the sum of labor and capital inputs. The author does not incorporate this concept in his analysis, however, but relies instead on more traditional measures of physical output per hour of labor.

Chapter 2 identifies the major obstacles to productivity increases, focusing attention on the controversial issues of grape boycotts, organization of farm labor, consumerism, pollution control, environmental protection, and pilferage. No quantitative estimates are given of the effect of these actions on costs or prices, but the exposition does serve to identify the problem of conflicting goals in society.

The next seven chapters discuss in detail the techniques and opportunities for increasing productivity in the areas of manufacturing and processing, standardization, transportation, warehousing, retailing, governmental regulation, and organized labor. Each chapter identifes the opportunities for increasing efficiency through introduction of improved techniques at the firm and industry levels. Limitations and restrictions on widespread adoption are also presented.

The concluding chapter offers recommendations for government action to improve productivity. These are (1) appointing an industry task force to establish industry and national productivity goals, (2) increasing research focused on identification and implementation of improved techniques and organization, (3) providing tax relief to stimulate investment in technology, (4) passing legislation to strengthen the bargaining power of employers, (5) practicing an enlightened antitrust enforcement policy to encourage joint actions among firms that would increase productivity, (6) encouraging the development of the unit train concept and intermodal terminals, (7) increasing educational efforts to promote a broad understanding of the importance of productivity, and (8) examining any new laws and regulations for possible detrimental effects on efficiency.

The breadth of the first two chapters which discuss productivity problems with respect to goals of society may leave the reader somewhat disappointed, for all of the major issues raised are quickly abandoned as the succeeding chapters focus on very specific techniques. The author vacillates between emphasizing the importance of increasing productivity and apologetic recognition that both management and society have other goals that often relegate productivity to a minor role. "It must be recognized that neither manufacturer, retailer, nor consumer places a high priority on productivity and efficiency in overall objectives" (p. 66).

Conclusions and recommendations in the book often go far beyond the supportive data. Although specific reference to a survey is frequently found, there is no statement as to the size or representation of the sample. Quotations from an individual business executive are extrapolated to the entire industry, and data for a single firm provide the basis for conclusions such as: ". . . steady progress has been made in physical productivity in manufacturing but warehouse handling remained on a plateau from 1967 to 1969" (single-firm data from Table III).

Despite the assertion on the dust jacket that "Dr. Bloom . . . writes . . . from a position of detached objectivity . . . ," his past experience as an executive in the food industry is reflected in the book, not only by implication through the tone of the discussion, but even more by the issues he chooses to discuss. This is particularly evident in the analysis of government's role related to the Federal Trade Commission. For example, in the National Food Commission Report the FTC concludes that "'economies of scale are generally insignificant in the food manufacturing industries." Bloom dismisses the FTC statement by referring to the statements of a number of executives who indicated that mergers are motivated by the need to improve physical productivity (p. 79). The chapter on Productivity and the Law asks the question, "'Has the impact of such laws on business activity tended to inhibit . . . efficiency and productivity?" (p. 244). A number of specific cases are cited where the Robinson-Patman Act has prevented firms from making vertical and horizontal agreements that would have increased productivity. Examples show that productivity was undoubtedly restricted, but the author specifically omits the topics of competition, industry structure, price rigidity, and market power from his discussion, preferring to treat productivity as an independent entity.

The author and publishers are to be commended for their ability to shorten the lag time between writing and publication. Use of photographic reproduction and minimal editing compensated with timeliness any loss in quality of type and the finer points of headings, italics, etc. However, the book could have benefited from a more careful organization of topics and rewriting in some places to improve the flow of ideas. Chapters 1 and 2 seem especially disconnected with a large number of topics whose relevance to one another is not always clear.

Many broad issues are raised but never discussed in sufficient detail to make clear their relevance to the topic. Chapter 1 identifies the conflicts between social and private productivity, but the discussion lacks cohesiveness. The issue is not resolved for the reader and is ignored throughout the remainder of the book.

There are a number of other unsatisfied expectations in the book. Although closer coordination among vertical elements in the marketing chain is promoted as a source of increased productivity, one looks in vain for any data comparing the efficiency of existing vertically integrated firms with independent units. Such data could provide empirical evidence of the efficacy of the recommended solution.

Agricultural economists might also feel uncomfortable with the role assigned to farm production in the proposed scheme to coordinate the food distribution system. Agriculture was omitted from the study, first because productivity has been so much higher than in other industries and second because "farming still represents . . . a struggle of man against nature . . . (and) problems therefore are different . . . ." Even if this justified the omission, the importance of including production scheduling in a total food distribution system should have required at least token recognition.

The chapter on Labor and Productivity includes a very interesting section on organized labor although again reflecting a point of view more readily endorsed by big business than other segments of the economy. The author details the manner in which unions reduce productivity by preventing management from utilizing the most efficient methods, from introducing new technology, and from using the workforce effectively. Bloom suggests the following types of affirmative action to cope with these labor restrictions: "(a) restoration of a balance of bargaining power; (b) exposure to public opinion; and (c) education of workers" (p. 285).

In summary, the book is worth reading for its review of technological innovation on the horizon for the food industry, for its identification of potential cost savings through a systems approach to distribution, and for its stimulus of suggestive ideas of the basic issues that must be faced in the decision to organize for higher levels of productivity.

Lowell D. Hill
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Brown, Lester R., *World Without Borders*, New York, Random House, 1972, xviii + 395 pp. ($8.95)

Lester Brown, toward the end of his book *World Without Borders*, discusses the "need for perspective"—the need for perspective "to see the world even as it is today, much less as it will be tomorrow." I would say that the purpose of *World Without Borders* is to provide that perspective. And it goes a long way toward achieving that high purpose.

To provide this perspective, Brown describes and discusses the great number (and rapidly increasing number) of socio-economic-environmental problems and issues which confront modern man and transcend national borders. But his technique is not a dull cataloguing of problems and issues. He develops a general analytical structure for relating these international problems and issues one to another and in support of his central thesis. This structure assumes the following form: first, an inventory of mankind's problems; second, promising approaches for dealing with those problems; third, the requirements of a global economy; fourth, the needed global infrastructure; and fifth, a discussion of philosophical and ethical issues. In terms of this analytical structure he develops his central thesis, which in the words of William McChesney Martin is the following:

> It could even be said that what were once the principal objectives of sovereign powers—the maintenance of economic prosperity and of effective defense—can now only be achieved by the acceptance of cooperative international arrangements which by their very nature impose limitations on the sovereignty of all the nations concerned.

In developing the above thesis, Brown brings a vast and imposing array of facts, data, and information to bear upon his discussion. This factual material and information ranges from energy production and use, to measures of pollution, to measures of real income, to the distribution of wealth and resources, to food production and consumption, to population trends, to resource usage and reserves, to the multinational corporation, to the technical aspects of global communications, and to a review of existing and needed international institutions.

Brown's command of factual material from many and varied fields is for this reviewer truly impressive. Where I could readily check factual material in my fields of specialization, I found it to be both accurate and properly handled. This generous use of factual material did not, however, put me to sleep, because the factual material presented was selected with skill to support the argumentation, and the text in which it is presented is a model of good writing. In fact, it is the author's clear, beautiful writing that really pulls the reader along over wide reaches of the globe, over a vast array of facts and data, and over a mind-numbing set of problems and issues.

Are we to conclude that the book has no shortcomings? No, not quite. This reviewer, who has become something of a cynic in his old age, became rather weary of the recitation of "right-thinking" actions and enlightened decisions that all of us must be a party to if we are to achieve a tolerable state of affairs in this world without borders. The number of "right-thinking" actions that must be taken and the number of enlightened decisions that must be made are so great as to leave the reader with a sense of frustration, if not despair. Along this same line Brown lectures those of us from the affluent Northern Hemisphere repeatedly about the need on our part for sacrifice in the control and use of resources if a "'good society" on a world basis is to be achieved. But he lectures those from the less developed world not at all about their need to sacrifice the present for the future to accumulate capital and worldly goods and to achieve disciplined rather than soft states. Achievement of a tolerable state of affairs in a world without borders will certainly be dependent upon some sacrifice of income and wealth on the part of the affluent in the Northern Hemisphere, but it will just as certainly require sacrifice and discipline on the part of those living in poverty in the Southern Hemisphere. There is no other way in the real world.

But what is in this volume for agricultural economists? Certainly it is not a technical book on economics. Neither is it a technical book on agriculture. The agricultural economist can find something very important in this book if he is able to get his mind off of exquisite, minute economic mechanisms for a brief spell. He can find directional guides to exciting and purposive work as an agricultural economist. A book such as *World Without Borders* could well direct a young foreign graduate student into nontraditional avenues of work that would be productive for him and his country; it could give new purpose to the work of a middle-aged, frustrated American agricultural economist; and it could assist a research director or a department head to open up some new and productive lines of economic research work. These would not be small accomplishments. And *World Without Borders* has this potential.

Willard W. Cochrane
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Haveman, Robert H., *The Economic Performance of Public Investments: An Ex Post Evaluation of Water Resources Investments*, Baltimore, The Johns Hopkins Press for Resources for the Future, Inc., 1972, xiv + 126 pp. ($7.00)

Public investments in water resource developments must be decided, like all long-lived investments, on the basis of *ex ante* forecasts of expected benefits and costs. There is no way of making all these forecasts completely error free. Haveman argues, however, that an *ex post* review of actual project performance could help greatly to uncover areas where forecasts can be improved. He is not the first to suggest this, but he is certainly one of the first to do anything about it.

Haveman terms this an "exploratory effort" and a "pilot study." After discussing some of the basic principles and problems involved, he devotes one chapter each to *ex post* evaluation of flood control investments, navigation improvements, hydroelectric projects, and project costs. Each chapter briefly presents the principles, concepts, and procedures to be used in evaluation and a case study. The number of observations is limited—one flood control project, one navigation project, 12 hydroelectric projects, and 86 cost studies. All are U. S. Army Corps of Engineers projects.

Haveman concludes from his investigations that *ex ante* estimation of project benefits is seriously flawed. He found wide deviations of actual from expected in both costs and benefits. Moreover, in the case of benefits, he detected a consistent bias toward overestimation. The overestimation was due in some cases to the use of procedures that "have little, if any, relationship to any efficiency concept of benefits or any other benefit concept that has economic meaning."

The analyses applied in this study are limited, as is understandable in an "exploratory effort." The finding of overestimated benefits in the flood control project rests heavily upon the fact that flood-level flows occurred less frequently in the 20-year post-project period than in the 40-year pre-project record that the Corps used to estimate flood frequencies. The case presented for the 20-year post-project record as the best estimate of true flood probabilities is not totally convincing. The sample study brushes over several aspects of flood projects that present the most perplexing projection problems. For example, improvement in productivity of flood plain lands is excluded from the analysis although it is a matter of considerable controversy at the *ex ante* stage of evaluation.

The chapter on navigation is aimed more at a comparison of proper to improper procedure than of *ex post* to *ex ante* analysis. The procedure in question is the determination of savings on water borne traffic. If, as current law requires, established freight rates are used rather than costs, waterway benefits will be overestimated. But this is true whether one is making an *ex post* or *ex ante* analysis. Focusing attention exclusively upon this error diverts attention from the main theme of the book. Several aspects of navigation analysis that would be more enlightened by *ex post* analysis are left completely untouched as a result. For example, it would be most interesting to know how well *ex ante* estimates predicted actual traffic movement in total and by waterway.

In general, this work fulfills its self-expressed role of an "exploratory effort." It is neither complete nor definitive. As might be expected in an "exploration," it encounters some impassable barriers, leaves intriguing areas unexplored, and in general leaves a winding trail. But it does point out the general directions to be taken in *ex post* analysis of water resources investments. Hopefully, more work will be forthcoming to fill in the procedural gaps that remain and provide more definitive assessments of *ex ante* analytical procedures. Similar investigations of other types of public investments would also be worthwhile.

Walter R. Butcher
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Jones, William O., *Marketing Staple Food Crops in Tropical Africa*, Ithaca, Cornell University Press, 1972, xiii + 293 pp. ($12.50)

This study helps to throw considerable light on the economics of marketing indigenous foodstuffs in tropical Africa. In the past this subject has been characterized by so much ignorance that intelligent government marketing policies could hardly be formulated.

Dr. Jones has analyzed the basic field data gathered by a number of investigators from the University of Illinois, the University of West Virginia, Michigan State University, and the Stanford Research Institute. The Institute also provided the general direction of the study for which the research design was prepared by the Food Research Institute. The field work was carried out primarily in 1966 and 1967 and concentrated on Western and Eastern Nigeria, Sierra Leone and Kenya, areas in which the degree of commercialization of food crops and of government intervention in the market differs considerably.

The study casts strong doubt on many notions that have gained currency in the past and have been used to justify government restraints on the private marketing mechanism and the provision of certain types of infrastructure and facilities. Thus it finds that (1) there was little evidence of widespread exploitation of farmers by middlemen through monopolistic or monopsonistic price-fixing; (2) seasonal price changes were not unreasonable in the light of crude estimates of storage costs, and the farmers themselves tended to store the bulk of food crops for disposal during the off-seasons; (3) there were usually no more than two middlemen between the farmer and consumer; (4) transport and physical market facilities were not for the most part serious constraints on the development of markets, and (5) lack of commercial credit and inadequate market information have at times prevented "spatial arbitrage" and thus the proper equilibration of supply and demand among markets.

The study in essence concludes that the system of "freely arrived-at transactions among private buyers and sellers" has worked well and needs only to be aided by government facilities and service.

While the book makes an important contribution to an understanding of food marketing in tropical Africa, it hardly pretends and cannot be deemed to be exhaustive. Subjects investigated must be pursued in greater depth. The geographic scope of the study must be broadened, particularly considering the wide variations in the production and marketing of food crops found in Africa.

To this reviewer it is unfortunate that the present study was limited in two respects. First, it was assumed that all persons in the marketing process "could be expected to display economic motivation of intensity and variability similar to that of inhabitants of the developed countries" (p. 17). This assumption may well be accepted for many areas in black Africa, particularly Nigeria, but my experience indicates that it can by no means be universally adopted. Second, the inquiry excluded investigation of the "determinants of marketable surplus," including responses of farmers to variations in prices, on the not altogether convincing grounds that this subject could not be examined until much more quantitative data and more information about the marketing process itself are available (p. 18). In my opinion the presence of a considerable number of investigators in the field could have provided useful opportunities to explore this subject. Certainly greater knowledge about elasticities of supply and demand is essential to an adequate understanding of marketing.

John C. de Wilde
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Mishan, E. J., *Cost-Benefit Analysis: An Introduction*, New York, Praeger Publishers, Inc., 1971, viii + 364 pp. ($12.50)

The economics profession has finally received a rigorous, and at times, nonintroductory text on cost-benefit analysis written by one of the most productive and insightful scholars in welfare economics. Mishan's book should have widespread adoption in courses encompassing applied welfare theory at the beginning graduate level. Topics are systematic in presentation commencing with simplistic (and at times misleading) examples of typical cost-benefit analyses followed by introductory discussions of consumer surplus, external effects, investment criteria, uncertainty, and concluding with a final section containing a *potpourri* of "Further Notes." As can be expected in a first effort, the degree of rigor, consistency, and clarity of the various topics appears to oscillate widely. This is apparently due to several factors. First, the book contains a substantial amount of Mishan's already published research melded together with intervening paragraphs. These paragraphs do not always lead the reader through an orderly progression of thought. Second, topics that Mishan has not published on previously are glossed over and in certain instances omitted entirely, e.g. multiple objective planning, stochastic system design and implementation problems, and applications of alternative cost doctrines. Third, the style is very turgid in some explanations. For example, in discussing "change induced benefits" on page 63, Mishan writes: "In such circumstances, the avoidable loss of quasi-rents by the London electricity authority which have to be borne because of the 'unnecessary' emigration from London (of those families which, if offered marginal cost prices, would have stayed in the London area) and which may not be covered by the excess benefits of the Brighton electricity project when calculated by reference to an uncorrected demand schedule, have to be accepted as an inevitable consequence of the institutional constraints." Needless to say, the book will not have a wide readership beyond first year economics graduate students.

Mishan's book is highly literary in content. There are less than fifty symbolic equations or formulae in the 52 sections, including those such as the benefit-cost equation which are repeated. In discussion of external effects, Mishan's application of symbols is not easily understood unless the student is familiar with calculus and partial derivatives, and yet his derivations add little to the textual description. He also identifies an external effect exclusively in terms of objects and not in terms of nonmaterial or nonrational events or ideas. For example, "envy" is considered not to have "moral approval" as an external effect. While in most instances qualifications or ancillary assumptions are set forth, they often are loosely stated following a conclusion in the earlier chapters. This is especially evident when one observes that the benefit-cost ratio is discussed as a concept (with numerical examples) in the first chapters but not introduced formally until after page 181 in the text.

In my opinion, the book contains an excellent survey of most of the salient developments in benefit-cost analysis through about 1967 with substantial emphasis on the conceptual foundations of Pareto efficiency and consumer surplus with only fleeting glimpses of the "measurement question." Mishan has a paraphrase of Dorfman's "Horse and Rabbit Stew" question, which would leave most lay readers and students in the dark as to why such a question was raised. Rather than deny that because of the "horse" (other social effects), the "rabbit" taste (or measurement of economic benefit) is completely lost, Mishan asserts with several arguments that such measurements of "rabbits" (economic benefits) might prove to be useful. First, they demonstrate ignorance. Second, guesses might be valuable. Third, order of magnitudes of relevant problems may be at least scaled and compared. Fourth, if all else fails, economists may have to step down into the cellar of social science research and actually ask the affected parties what their losses and gains were, are, or will be!

Perhaps the greatest omission in Mishan's book is an analytical treatment of empirically measuring benefits and costs. Neither indirect nor direct methods of measurement are analyzed, and the various innovative schemes for indirect measurement such as differential rents and the Hotelling-Clawson-Knetsch model for valuing recreational visits are not given explicit coverage. Yet, it is in measurement problems (at least if one accepts the validity of the consumer surplus concept) where the "horse" really smells! Most of the intricate discussion of what to count or measure and what not to in the early chapters could have been generalized and clarified by a clear statement of the "with and without principle." Another objection is that Mishan readily accepts the application of the compensating variation (CV) measure of consumer surplus as the relevant one for assessing a "potential Pareto improvement." He apparently draws this conclusion because CV measures gains and losses in the "presence of change" with reference to compensating changes in utility after the change had in fact occurred. Pareto improvements can only be assessed with reference to altering utility to its level in the initial state, and therefore the CV measure is applicable. I am not convinced. First, should Pareto improvements be defined over a constant utility level in *retrospect* or in *prospect* in benefit-cost analysis? I would assert that in most instances benefit-cost analysis should be applicable to prospects. But if this is so, the EV measure might be more appropriate. This problem can be illustrated with two hypothetical statements regarding the construction of a dam that has a negative impact on local residents. The CV measure would require the following question (ignoring nontruthful answers): A dam is going to be built (event). How much will you need to be paid (substitution) so you are as well off as you would have been if the dam were not constructed? The EV measure would require the alternative question: No dam is going to be built (no event). How much would you pay for not building it (substitution) so that you are as well off as if it had been built? Note, under the CV measure, the event is already present while the EV measure includes its presence only as a base for measurement. The central question then is whether Pareto improvements be measured as the effects of deviations from current states in the absence or presence of the deviation, since the deviation itself embodies a change in utility? I do not perceive an ethically dominant choice emerging for either EV or CV measures without further information being introduced.

Application of the CV or EV measure of loss implies a different configuration of property rights. The CV measure gives implicit right to the governmental agency or public authority applying the benefit-cost analysis to alter someone's utility negatively and then provide or not provide compensation. Alternatively, the EV measure does not contain this implicit right but allows the agency to estimate willingness to pay. Second, there is the problem of irreversibility once someone's utility has been changed, which is inherently a problem with CV since under CV utility needs to be restorable, but not necessarily under EV. A third negative aspect of the CV *or* EV measure of consumer surplus is that neither measure as now constituted contains an explicit recognition of the substitutability issue. Both presume the existence and uniqueness of substitutes for the "event" or action considered. What measure is appropriate if cultural constraints allow no substitutions, i.e. sacred Indian burial grounds inundated by dam construction? A final problem with both the EV and CV measures in benefit-cost evaluation is that both are dependent upon the underlying assumptions of the political dogma that individual preferences are tantamount in importance in evaluating both individual and societal gains and losses. Mishan does very little to inform the student of the very long list of psychic and political qualifications (except for external effects and liability rules) necessary to select appropriate measures of social benefits and costs, or what happens to the validity of the various concepts including consumer surplus when the qualifications are perturbed.

With the exception of an occasional vague or incompletely qualified statement such as "maximizing the benefit-cost ratio," Mishan has written a tightly woven and articulate orthodox text. I recommend his book to all who have the patience to read it thoroughly.

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Owen, John D., *The Price of Leisure*, Montreal, McGill-Queen's University Press, 1970, x + 169 pp. ($9.00)

The study presents a new approach to the analysis of the demand for leisure time as determined by development of the commercial recreation industry, fatigue, education, commuting, working conditions, productive consumption, and unemployment. The first chapter rationalizes the equation of leisure with consumption time (time devoted to consumption- rather than income-producing activities). There are several conceptual problems with the definition of leisure as a consumption good.

Veblen's concept of leisure (*The Theory of the Leisure Class*) is not examined but is identical to Owen's definition. It may be that predominance of Veblen's conspicuous leisure over the Puritan work ethic is more useful than economics in explaining the forces underlying Owen's description of the trend to a seven-hour day, four-day week, one-month vacation and retirement at age 60.

Workers do not purchase leisure time as noted by Owen. However, it is assumed but not explicitly stated that the derived employer demand for labor is not monopsonistic and that wages (conversely, the price of leisure) are determined by competitive forces. Furthermore, unions have monopolistic characteristics which are likely to be a very important determinant of leisure. The implications of these assumptions merit greater attention in the study, particularly since the study period 1929–1961 illustrates a substantial increase in labor's bargaining power. In short, the theoretical discussion jumps from the microeconomics of individual work-leisure choices to estimation of macroeconomic aggregates. Confusion in the theoretical analysis is carried into the empirical section in which the terms "demand for leisure" and "supply of leisure" are used in reference to the same set of equations.

In deriving estimates of leisure time, an excellent review of factors underlying trends in average man-hours of employment is given, including: labor force participation, fringe benefits, working conditions, education, and unemployment. Examination of the commercial recreation data is not as thorough. The United States Department of Commerce series on estimated recreation expenditures is used as a measure of market purchases associated with leisure. The stock-flow problem associated with recreation purchases and recreation use of goods not in the recreation expenditure category is inadequately treated. No mention is made of consumer surplus commonly used in evaluating recreational activities as well as satisfaction associated with alternative market wage levels for labor.

Four single equation models of demand for leisure time with a full employment and an annual series are estimated. The first model includes wages only; the second adds the price of recreation; and the third deflates the wage rate and the price of recreation by a price index adjusted to include the price of leisure. A fourth model incorporates a fatigue effect in estimating the relationship between hours of work and wages. The fatigue effect is designed to adjust for a nonproportional relationship between output and hours of work.

It is not clear from the text whether the statistical analysis is used to test or generate the hypotheses that income effects of wage increases have outweighed substitution effects. A positive relation is found between the wage rate and the demand for leisure and a negative relationship between the price of recreation and leisure.

An equation representing employer demand as a function of the capital labor ratio, employment man-hours, education, and residual economic growth is estimated. The equations are extensions of studies by Dennison, Kendrik, and Goldsmith. Supply of labor and demand for labor functions are then solved simultaneously. Next a market recreation model is formulated in several forms. Recreation expenditures are regressed on income and the price of recreation, and hours of leisure time. Lastly, a model of the demand for leisure activity is estimated by regressing leisure activity (a weighted average of leisure time and market recreation expenditures) on wages, price of leisure activity and, alternatively, the price of leisure and recreation. Estimates of the elasticity of substitution between leisure time and market recreation are then derived. The estimates appear reasonable, but insufficient reference is made to results of other studies.

The study provides an innovative approach to economic analysis of both leisure time and recreation expenditures and should be of considerable interest to economists conducting research in labor and resource economics.

JAMES A. MACMILLAN
University of Manitoba

Telser, Lester G., *Competition, Collusion, and Game Theory,* Chicago, Aldine • Atherton, 1972, xix + 380 pp. ($12.95)

Competition, Collusion, and Game Theory is not a book for quiet reading by the fire. Rather, it is a rigorous, mathematical treatment of the subjects suggested by the title and demands the closest reading. Those who, like this reviewer, will find a good many of the formal proofs disconcerting testament to their antiquity, can nonetheless profit a great deal from the arduous task of careful reading.

The book consists of eight chapters. The first three are applications of core theory to problems of market exchange and oligopoly. Chapter Four concerns equilibria with various conditions of oligopolistic expectations and various numbers of firms under static demand conditions with, first, perfect substitutability and, second, imperfect substitutability among the goods of oligopolistic competitors. The fifth chapter treats the costs of collusion to potentially participating firms, the conditions under which competition rather than collusion is likely to result, complexities arising from product variety among firms, and the theory of sharing monopoly returns from effective collusion. Chapter Six deals with dynamic demand relationships in oligopolistic structures with perfect and gross substitutability. The final two chapters are empirical studies—not closely interwoven with the preceding theory—of price and market share interrelations for four advertised consumer products and of relations among rates of return, concentration, and other structural variables for a large number of four-digit, SIC industries.

My own reading enjoyment came mainly from the first three chapters and, from them, largely from learning more about the theory of the core. Indeed, aside from deeper insights into the Cournot-Nash Theory of Duopoly involving such things as empty cores, the feasibility of trade and the proper interpretation of sequential periods in the Cournot system, startling new results are notable by their absence.

In Chapter Four Telser proves somewhat surprisingly that static Cournot expectations yield a convergent solution only for the two firm case. When expectations adapt to the past responses of rivals, convergent solutions may result regardless of the number of firms. These are refinements of some importance in the theory of oligopoly.

Chapter Five is less rewarding. The theory is a good deal tighter, but the most important results concerning whether collusion will be successful are those presented by William Fellner in *Competition Among the Few* (1949) and by George Stigler in "A Theory of Oligopoly," *Journal of Political Economy* (1964). Telser does add an analysis of merger as an alternative to cartel agreements which, though again far more rigorous theoretically, is in the vein of Ronald Coase's "The Nature of the Firm," *Economica* (1937).

Chapter Six convinces one that optimizing behavior in a dynamic setting is an extraordinarily complex problem. The most interesting proof is that a rental policy is never dominated by an outright sales policy in a monopoly setting. The most interesting problem is the nature of price expectations that imply an equilibrium in an oligopoly setting.

Chapter Seven estimates price elasticities on market share data for established and for new branded consumer products. Given the nature of the products and Telser's previous interests in advertising, it is surprising that no attention is given to advertising and to relations between advertising, price elasticities, and market shares. Still, it is interesting that the price policy apparent for new products is entry-retarding rather than entry-preventative and that the market share demand relation for established products can be described as a first order distributed lag with residuals generated by a Markov process.

The concluding chapter consists of a regression analysis of the effects of market structure on industry performance. Rates of return are shown to be positively related to concentration; tangible capital and specific human capital per employee tends to rise with concentration; and establishments in concentrated industries are less specialized than are those with low concentration. Number of firms as well as concentration is used in the rate of return regressions, and it is found that the partial relationship is one in which larger numbers are associated with higher rates of return. Telser's conclusion that this reflects entry where rates of return are high is unconvincing and in fact unsupportable with his single equation regression approach.

Throughout the book there are repeated places where additional references to previous treatments of the subject matter—in contrast to references relating to mathematical proofs—would be helpful. But this is nibbling criticism. The book is a good one and merits the serious attention required in its reading.

ALMARIN PHILLIPS
University of Pennsylvania

Tomek, William G., and Kenneth L. Robinson, *Agricultural Product Prices,* Ithaca, Cornell University Press, 1972, xi + 376 pp. ($14.50)

The authors' decision to write this book was motivated by two considerations. First, they believe that the behavior of agricultural product prices is sufficiently unusual to require special treatment. Second, the authors saw a need for a more up-to-date text, which combines principles of price determination, information on pricing institutions, and an introduction to selected quantitative techniques as applied to agricultural prices. The book is aimed at an intermediate level course in agricultural prices and marketing. Students should previously have had a course in microeconomic principles, but no mathematical competence beyond plane geometry and ordinary algebra is required. In this reviewer's opinion, they have produced one of the best books in agricultural prices available at this level.

Following the introductory chapter, the book is divided into four sections. The first is concerned with principles of price determination and encompasses four chapters. Elements of demand theory are reviewed and related to the demand for agricultural commodities in Chapter 2. In the discussion of derived demand, little attention is given to the underlying production functions and to supplies of inputs. A comprehensive treatment of demand elasticities and price flexibilities is presented in Chapter 3. This is one of the better chapters of the book, and it might have been strengthened even further if a detailed derivation of income and substitution effects had been presented in an appendix. With a liberal use of illustrations, the concepts underlying supply relationships in agriculture are masterfully discussed in Chapter 4. Chapter 5 concludes this section with a highlighting of the theory and practice of price determination for different types of market structures.

The next section of the book contains five chapters and focuses on price differences and price variability. With effective use of figures and illustrative examples, a thorough coverage of marketing margins for farm products is given in Chapter 6. Price differences associated with quality are discussed in Chapter 7, while price differences between regions and spatial price relationships are considered in Chapter 8. Discussion of price variation through time in Chapter 9 tends to be heavily mechanically oriented (mechanically accounting for wiggles and waggles in prices), and structural analysis is not mentioned until the latter part of the chapter; then only a cobweb model is considered. This section ends with a lucid discussion of aggregate farm price behavior with particular attention devoted to the impacts of inflation and deflation on agricultural prices and the relative position of agriculture.

The third section of this book consists of four chapters concerned with pricing institutions. The first of these chapters (Chapter 11) consists of a description of different mechanisms for discovering or establishing farm prices. Chapters 12 and 13 deal in a rather comprehensive way with the mechanics, price relationships, and functions of commodity futures markets. A framework for assessing the economic consequences of alternative forms or degrees of government intervention in pricing farm products is presented in Chapter 14.

The fourth and final section of the book consists of two chapters concerned with an introduction to empirical price analysis. Chapter 15 focuses on the formulation of models and alternative techniques of analysis. Chapter 16 is a mini-course in regression analysis with applications to price analysis. The whole section is oriented to single equation types of analyses with structural analysis involving simultaneous systems of equations completely omitted.

Agricultural Product Prices is well organized and written. It is a suitable text for an undergraduate or possibly dual level (undergraduates and beginning graduate students) course in agricultural prices or price analysis. For graduate students the book would need to be complemented with the detailed development and derivation of many of the concepts presented in a summarized verbal form. Also, this book might be good supplemental reading in agricultural economics courses other than agricultural prices or price analysis.

JOSEPH HAVLICEK, JR.
Purdue University

Wellford, Harrison, *Sowing the Wind*, New York, Grossman Publishers, 1972, xxiii + 384 pp. ($7.95)

According to the dust cover, Harrison Wellford is one of the five original "Nader's Raiders." His book is an interesting blend of description, in the best tradition of American muckraking, and insightful analysis of technical problems and political processes related to the modern U. S. food system. Thus it is both interesting reading and instructive. Nor does Wellford shy from making recommendations for improving what he considers to be a deplorable state of affairs in the procedures for consumer protection from food contamination.

The book is something of a mixed bag. The first four chapters deal with various aspects of meat inspection. Some of the description of current practice would not be out of place in Lewis' *The Jungle*. One major theme is that often a great difference exists between enactment of a consumer protection law and implementation of the promise implied in the law. I believe this is an important theme for all those interested in policy; we have paid much too little attention to the problems and processes of policy implementation.

Chapter 5 deals with the plight of the poultry contract farmers. The description is reasonably accurate, and some points are made about problems of economic concentration. The purpose of this chapter in the context of the book is not clear unless it is to emphasize that Wellford is concerned with the problems of farmers as well as consumers. Chapter 6 deals mostly with problems associated with chemicals in meats. Chapters 7 through 13 deal with various aspects of policy and regulations related to pesticides.

Wellford makes extensive use of case studies which he uses to support or illustrate a set of themes or propositions about the regulatory processes related to food and environmental safety. The book might be faulted for a lack of systematic treatment of its major themes. The style tends to be journalistic rather than academic. But academic writing has not proven to be particularly effective in influencing opinion or regulatory practice.

Several cases illustrate that highly competitive market conditions combined with products which have quality characteristics difficult to judge by consumers creates pressures leading to quality deterioration. Thus competition in the real world of imperfect knowledge does not necessarily result in desirable performance.

There are good guys and bad guys in the book. The large agri-business firms, their lobbyists, and the regulators (and congressmen) who come under their influence are generally cast as bad guys while consumers, farm workers, small farmers, and regulators who resist the pressures of the special interests, especially if such resistance results in leaking inside information or threatens their jobs, are the good guys. To say this, however, is misleading, since much of the emphasis is on the problems of the system and the processes rather than on the goodness or meanness of human nature.

Issues and problems dealt with by Wellford are important ones. Most important is the question of how a society regulates the uses of modern technology. How do we assess the risks, and whose preferences count in determining the uses of chemicals with unknown future effects? The problems of externalities associated with the technology of the modern food system are of enormous importance. Much too little has been invested in either the technical assessment or the economic-political analysis of the consequences of the uses of these technologies.

My favorite explanation of the fall of the Roman Empire is the one attributing it to a failure of consumer protection. The hypothesis is that cooking utensils containing lead were introduced resulting in lead poisoning which contributed to a deterioration of the mental capacities of the upper classes of the Empire. I do not know how to test this hypothesis, but we do know: (1) utensils containing lead were introduced and were used by the ruling classes of Rome; (2) lead poisoning, which causes deterioration of mental capacity, could have resulted; and (3) there is ample evidence of poor decisions by the Roman ruling classes. We too may suffer the fate of the Roman Empire for lack of an understanding of the long-run consequences of our technology. Wellford has provided a book with a wealth of hypotheses, observations, and recommendations which deserve attention by those concerned with the future of our civilization.

I am sure there are many who would fault the book as being unfair and biased. No doubt there is another side to some of the cases presented in the book. Both sides of many issues are presented. One of Wellford's themes is that the consumer protection and environmental activists have approached the problems in too simplistic a fashion. He recognizes the importance of trade-offs and careful benefit/cost analysis. He does not, for example, argue for the complete elimination of DDT but rather calls for its use only where the benefits exceed the costs. But he wants all the costs and alternative methods of insect control to be considered. Unfortunately the arguments on both sides of these issues often lack this application of basic economic reasoning. In fact, one of the major issues raised by the book is the question of how a democratic society can deal with extremely complex issues of this type. How can we get beyond the slogans? How do we develop the processes of decision-making to utilize the inputs of the technical experts and keep the basic questions of preferences within an effective political context? Establishing the probability that food chemicals will cause cancer, for example, is a highly technical question. Assessing the costs of alternatives is likewise a technical question. However, the decision that it is worth the risk of a 10 percent chance that 10,000 people will suffer from cancer as a result of using a pesticide in order to reduce the cost of food by 2 percent is not a technical question but a political one. Unfortunately we have to date failed in both identifying and presenting the trade-offs in understandable form and in structuring our political institutions to articulate effectively preferences among such alternatives.

Wellford's book raises several important questions for the agricultural economics profession. Why wasn't this book, or one on the topic, written by an agricultural economist? Why are we not investing more in the examination of these important issues?

The book is rich in hypotheses and observations suggestive of fruitful research. It is well worth reading.

JAMES D. SHAFFER
Michigan State University

Books for listing in this section should be sent to the Book Review Editor (see inside front cover for address).

Books Received

Becker, Gary S., *Economic Theory,* New York, Alfred A. Knopf, 1971, xii + 222 pp. $9.50.

Briggs, Jr., Vernon M., *Chicanos and Rural Poverty,* Baltimore, The Johns Hopkins University Press, 1973, viii + 81 pp. $1.95. Paper.

Bronfenbrenner, Martin, *Income Distribution Theory,* Chicago, Aldine•Atherton, Inc., 1971, xv + 487 pp. $14.75.

Clarke, Roger A., *Soviet Economic Facts 1917–1970,* New York, John Wiley & Sons, Inc., 1972, xi + 151 pp. $12.75.

Dorner, Peter, *Land Reform and Economic Development,* Baltimore, Penguin Books, Inc., 1972, 167 pp. $2.75. Paper.

Eaton, Joseph W., ed., *Institution Building and Development: From Concepts to Application,* Beverly Hills, Sage Publications, Inc., 1972, 271 pp. $15.00.

Farris, Martin T., and Roy J. Sampson, *Public Utilities: Regulation, Management, and Ownership,* Boston, Houghton Mifflin Company, 1973, xii + 355 pp. Price unknown.

Fuchs, Victor R., ed., *Essays in the Economics of Health and Medical Care,* New York, National Bureau of Economic Research, 1972, xxii + 239 pp. $8.00.

Goldblith, Samuel A., and Robert V. Decareau, *An Annotated Bibliography on Microwaves: Their Properties, Production, and Applications to Food Processing,* Cambridge, The MIT Press, 1973, xi + 356 pp. $14.95.

Hirsch, Werner Z., *Urban Economics Analysis,* New York, McGraw-Hill Book Company, 1973, xviii + 450 pp. $10.95.

Hopkin, John A., Peter J. Barry, and C. B. Baker, *Financial Management in Agriculture,* Danville, The Interstate Printers & Publishers, Inc., 1973, x + 459 pp. $10.75.

Indian Society of Agricultural Economics, *Comparative Experience of Agricultural Development in Developing Countries of Asia and the South-East Since World War II,* Papers and Proceedings of International Seminar held at New Delhi, October 25–28, 1971, Bombay, Thacker & Co. Ltd., 1972, xxv + 434 pp. $9.00.

Junk, W. Ray, and Harry M. Pancoast, *Handbook of Sugars: For Processors, Chemists and Technologists,* Westport, The AVI Publishing Company, Inc., 1973, xiii + 327 pp. $20.50.

Kazmier, Leonard J., *Statistical Analysis for Business and Economics,* 2nd ed., New York, McGraw-Hill, Inc., 1973, xv + 623 pp. Price unknown. Paper.

Kostrowicki, Jerry, and Roman Szczesny, *Polish Agriculture: Characteristics, Types and Regions,* Budapest, Akademiai Kiado, 1972, 120 pp. $5.20.

Machlup, Fritz, Walter S. Salant, and Lorie Tarshis, eds., *International Mobility and Movement of Capital,* New York, Columbia University Press for the National Bureau of Economic Research, Inc., 1972, xi + 708 pp. $20.00.

McKinnon, Ronald I., *Money and Capital in Economic Development,* Washington, D.C., The Brookings Institution, 1973, xii + 184 pp. $7.50.

Meadows, Dennis L., and Donella H. Meadows, eds., *Toward Global Equilibrium: Collected Papers,* Cambridge, Wright-Allen Press, Inc., 1973, x + 358 pp. $18.00.

Nader, Ralph, and Mark J. Green, eds., *Corporate Power in America,* New York, Grossman Publishers, 1973, x + 309 pp. $7.95.

Potter, Jeffrey, *Disaster by Oil,* New York, The Macmillan Company, 1973, xii + 301 pp. $7.95.

Rutstrum, Calvin, *The New Way of the Wilderness,* rev. ed., New York, The Macmillan Company, 1973, viii + 280 pp. $2.95. Paper.

Rutstrum, Calvin, *The Wilderness Route Finder,* New York, The Macmillan Company, 1967, x + 214 pp. $1.50. Paper.

Scott, Robert Haney, *The Pricing System,* San Francisco, Holden-Day, Inc., 1973, xv + 293 pp. $10.95.

Sinha, R. N., and W. E. Muir, eds., *Grain Storage: Part of a System,* Westport, The AVI Publishing Company, Inc., 1973, xiii + 481 pp. $23.50.

Smith, Robert S., Frank T. de Vyver, and William R. Allen, eds., *Population Economics: Selected Essays of Joseph J. Spengler,* Durham, Duke University Press, 1972, v + 536 pp. $17.50.

Stadelman, William J., and Owen J. Cotterill, eds., *Egg Science and Technology,* Westport, The AVI Publishing Company, Inc., 1973, vii + 314 pp. $17.00.

Symons, Leslie, *Russian Agriculture: A Geographic Survey,* New York, John Wiley & Sons, 1972, xii + 348 pp. Price unknown.

Taylor, Ronald B., *Sweatshops in the Sun: Child Labor on the Farm,* Boston, Beacon Press, 1973, xvii + 216 pp. $6.95.

Wädekin, Karl-Eugen, *The Private Sector in Soviet Agriculture,* 2nd ed., Berkeley, University of California Press, 1973, xviii + 407 pp. $17.50.

Weaver, James H., ed., *Modern Political Economy: Radical and Orthodox Views on Crucial Issues,* Boston, Allyn and Bacon, Inc., 1973, xii + 479 pp. $5.95. Paper.

Wu, Rong-I, *The Strategy of Economic Development: A Case Study of Taiwan,* Louvain, Vander, 1971, vii + 217 pp. 29 FR. Paper.

Announcements

AAEA-ASSA
1973 Winter Meeting

The American Agricultural Economics Association will meet jointly with the Allied Social Sciences Association in New York City in December. A complete program will be published in the November AJAE.

Sessions are scheduled in the following areas:

- Factor Productivity in American Agriculture (joint session with the Econometric Society)
- Domestic Energy Supply and Demand (joint session with the American Economic Association)
- Economic Impact of the U. S. Agricultural Trade in the 1970's.

Census Data Guidance Service

The Clearinghouse and Laboratory for Census Data (CLCD) is a public service organization operated by National Data Use & Access Laboratories through a grant from the National Science Foundation. CLCD provides support services to all persons engaged in research to understand or solve local, regional, or national problems to which census data may be applied. The CLCD is set up so that a user can call or write in about his research problem and get most of the assistance he requires to determine if the census can meet his needs, how to overcome technical barriers to using the census, and how much his use of the census will cost. Where fees are charged, they are set to recover marginal administrative costs not covered by the NSF grant. For further information contact Carolee Bush, Clearinghouse and Laboratory for Census Data, 1601 North Kent Street, Suite 900, Rosslyn, Virginia 22209; phone (703) 525-1480.

Rural Environmental Engineering

On September 26–28, 1973, "Rural Environmental Engineering: A Conference on Water Pollution Control Technology in Low Density Areas" will be held at the Sugarbush Inn, Waitsfield, Vermont. This conference will bring together nationally known environmental engineers and scientists with consultants, planners, local-county-state agency authorities to clarify the magnitude of rural water associated pollution problems and to present some of the new technologies available for describing and/or controlling such problems. For additional information contact Dr. William J. Jewell, Department of Civil Engineering, University of Vermont, Burlington, Vermont 05401; phone (802) 656-3800.

News Notes

ECONOMIC RESEARCH SERVICE, USDA

(EDD, Economic Development Division now part of USDA's Rural Development Service; ESAD, Economic and Statistical Analysis Division; FDCD, Foreign Demand and Competition Division; FDD, Foreign Development Division; FPED, Farm Production and Economics Division; MED, Marketing Economics Division; NRED, Natural Resource Economics Division.)

APPOINTMENTS: **Kathryn Kayser,** FDCD; **Roger P. Lewis,** FDCD; **Susan B. Tripp,** FDCD; **Steven Guebert,** Ph.D. Wisconsin, to Commodity Analysis Branch, ESAD; **Harold Taylor,** from the Land and Water Research Institute, Pennsylvania State University, to Farm Income Branch, ESAD.

REASSIGNMENTS: (The Economic Development Division of the Economic Research Service has been transferred to the Rural Development Service. RDS, along with the Farmers Home Administration and the Rural Electrification Administration, report to the newly designated Assistant Secretary for Rural Development, **William Erwin.** EDD will continue to administer programs of research and service related to rural people and rural communities.) **Dwaine E. Umberger,** FPED-Pullman, Washington, to Washington, D.C.; **Richard B. Smith,** FPED-Ames, Iowa, to Washington, D.C.; **Charles E. Overton,** MED-Lafayette, Indiana, to Washington, D.C.; **Alan Fox,** NRED-Ithaca, New York, to Forest Service, Ithaca, New York; **Berry T. Kuntz,** NRED-Jackson, Mississippi, to Corvallis, Oregon; **Rodney C. Kite,** MED, to ESAD; **William Faught,** MED, to FDD; **James Vertrees,** MED, to Planning & Evaluation Staff, MED.

RESIGNATIONS: **Henry D. Brodnax,** FPED, to Cooperative Extension Service (Mississippi); **William G. Bursch,** FPED, to Experience, Incorporated of Minneapolis; **Billy G. Freeman,** FPED, to Agricultural Economics Department, Texas Tech; **James Maetzold,** MED, to Price Commission; **Hazen Gale,** formerly Acting Chief, Outlook and Projections Branch, ESAD, to the Cost of Living Council; **Joseph P. Biniek,** NRED-Washington, D.C., to Library of Congress, Washington, D.C.

RETIREMENT: **Roz Lifquist,** MED; **Lawrence A. Jones,** FPED.

LEAVE: **Bruce H. Wright,** MED, granted one year to work at the Chicago Board of Trade.

UNIVERSITY OF FLORIDA

RETIREMENTS: **John R. Greenman,** professor, after 30 years of service; **A. H. Spurlock,** professor, after 39 years of service.

IOWA STATE UNIVERSITY

APPOINTMENT: **Raymond R. Beneke,** professor, as chairman of the Department of Economics, effective April 16, 1973, through June 30, 1978.

RETURN: **Geoffrey Shepherd,** professor emeritus of economics, after a six-month study of marketing and price policy in Venezuela, for the Inter-American Bank for Development, and CORPOANDES, an agency of the Venezuelan government.

MICHIGAN STATE UNIVERSITY

APPOINTMENTS: **Ahkter Ahmed Khan,** visiting professor for one year; **Richard Trimble,** assistant professor.

LEAVES: **David Cole** to Harvard University for one year; **John Ferris** to the Cost of Living Council, Washington, D.C., for four months; **Dan Sturt,** leave to U.S. Department of Labor extended for another year.

UNIVERSITY OF MINNESOTA

RETIREMENT: **Edmund A. Nightingale,** professor emeritus of economics and transportation, after 39 years of service.

OTHER APPOINTMENTS

Tridib K. Mukherjee, returning from the National Institute of Bank Management, Bombay, India, as associate professor of economics, Appalachian State University, North Carolina, September 1, 1973.

Alberto Valdes, Ph.D. London School of Economics, formerly with Universidad Catolica de Chile, to the Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia, as associate economist.

OBITUARY

H. Clyde Filley, emeritus professor and former chairman of the Department of Agricultural Economics at the University of Nebraska, died March 15, 1973, in Lincoln at the age of 94. His passing ends a long and fruitful career of service to agriculture.

Filley was born and educated in Nebraska and at the University of Minnesota where he received a Ph.D. degree in 1934. He did early teaching and administrative work in Nebraska secondary schools, earned his M.A. in 1911 at the University of Nebraska, and joined the University staff as an instructor in farm management. In 1914 he became the first chairman of the department, a position which he held to his retirement in 1949.

An excellent teacher and popular speaker, Filley's first research was in farm management. He helped farmers organize cooperatives in his early years and taught the first class in the U. S. in cooperative marketing. In later years he devoted his time in the department to administration, teaching, and research in marketing and policy. After retirement he served as Master of the State Grange and as economist for an insurance company. Filley was one of the last survivors of those pioneer agricultural economists who established departments of agricultural economics in the early years of this century and laid solid foundations for the scope and depth of agricultural economics of the present era.

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Real Property Taxes and Farm Real Estate Values: Incidence and Implications*

E. C. Pasour, Jr.

The relationship between reductions in real property taxes and farm real estate values is investigated. Average per acre value of farm real estate in North Carolina is regressed on the tax rate and other variables relating to farm size, land productivity, urban influence, and recreational demand. The results indicate that property tax reductions for farm real estate are largely capitalized into higher real estate values. The effect of a given decrease in tax rate for owners of farm real estate is contrasted with a similar decrease for owners of residential real estate.

PROPERTY tax relief has surfaced as a central political issue of the 1970's. The local property tax has been attacked by nonfarm as well as farm interests. Some of the pressure, especially by nonfarm interests, has emanated from the role of the property tax in financing local schools. Much pressure has also been exerted by farm interests to reduce the level of property taxes on agricultural real estate, especially in rapidly urbanizing areas. Little information is available, however, concerning the potential impact of "property tax relief" for farmers *vis-à-vis* other property owners.

The effect of a change in the level of property taxes on the owner of any form of real estate depends upon the amount of real property held and the extent (if any) to which the taxes are capitalized into land values. In some cases, the primary effect of a change in the tax rate is on the value of the taxed property. In other cases, the major effect is on rents instead of property values. There is a fairly general consensus among economists that increases in levies of property taxes on farm real estate are capitalized, at least to some extent, into lower property values. However, there has been very little empirical work to determine the extent to which farm real estate values are affected by changes in local property taxes.

This study was designed to provide information concerning the relationship between changes in the level of property taxes and the value of farm real estate in North Carolina. The results of the study and those of a companion study are then used to analyze the effect of a reduction in property tax rates on owners of farm real estate *vis-à-vis* residential property owners in North Carolina. The results are likely to be broadly applicable to agricultural real estate for other areas.

Tax Incidence

In view of the importance of property taxes both in financing local governmental services and as a cost component in agricultural production, economists have given surprisingly little attention to the incidence of property taxes levied on farm real estate. Empirical results are limited and inconclusive. Netzer cites only two studies. One study (by Jensen) found strong evidence of capitalization of farmland values during the period from 1919 to 1924. Another study in Michigan (by Daicoff) found little such evidence [3, p. 34]. A more recent study in Indiana found that increases in property tax collections were associated with decreases in farm real estate values [8].

There is general agreement among economists that taxes are capitalized into lower land values when levied on unimproved land where supply is perfectly inelastic (Fig. 1). The price of land before the tax is imposed is P_0 when the supply and demand of land are designated by S and D, respectively. Total supply of land is not affected by the imposition of a tax on land. Consequently, the stream of potential returns from the land will be reduced by the present value of this stream of tax payments which must be paid from the rent. Price of the land would then decrease by the amount of the capitalized taxes. In the situation depicted in Figure 1, the tax is

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E. C. Pasour, Jr. *is professor of economics at North Carolina State University, Raleigh.*

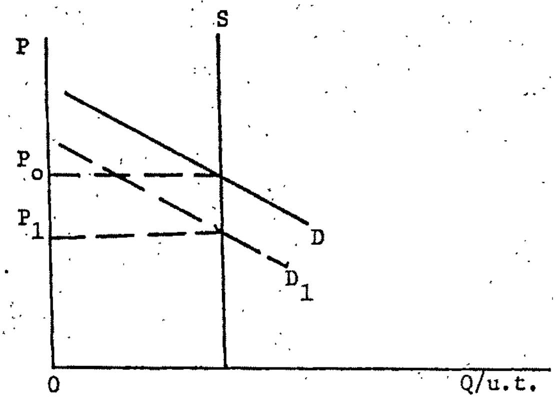

Figure 1. Capitalization of a tax on land in perfectly inelastic supply

fully capitalized and the value of the land is reduced from OP_0 to OP_1.[1]

The assumption that farmland is in perfectly inelastic supply is not completely correct. Large amounts of land have been reclaimed (e.g., by drainage). Furthermore, improvements in the form of fertilizer, drainage, clearing, and grading represent investments in reproducible capital which affect land values. The quantity of reproducible capital inputs used to improve land will increase in response to price increases for developed land. Furthermore, land shifts out of agriculture as the opportunity cost of farmland in other uses increases. If the supply of improved land is not completely inelastic, a tax on land will not be fully capitalized into lower land prices. This situation is depicted in Figure 2.

In the example depicted in Figure 2, the tax lowers the demand curve from D to D_1. As a result of the tax, the quantity of developed land falls (or does not increase as rapidly as it might have) from oq_0 to oq_1. The annual rental value of the land is increased slightly from Or_0 to Or_1 so that this portion of the tax is shifted. The remaining portion of the tax (Or_0 less Or_1) is capitalized into lower property values. The portion of the tax which is capitalized into lower property values will constitute the bulk of the tax so long as supply is quite inelastic.

The situation depicted in Figure 2 characterizes the farm real estate market. Buildings, land clearing, grading, and other reproducible capital constitute a portion of the value of farm real estate. Although the supply of reproducible capital is much more elastic than the supply of land, in practice it is difficult (if not impossible) to separate the value of land from the value of improvements.

One cannot determine on *a priori* grounds the incidence of property taxes levied on farm real estate. However, it appears likely that property taxes on farm real estate in North Carolina are capitalized to some extent into lower property values. The annual rent or return from farmland is equal to the expected return net of taxes. In determining the expected return, the North Caronina agricultural producer can largely take product price as given. Prices of most farm products produced in North Carolina are determined mainly by conditions of the national market instead of local conditions since the proportion of the total output produced is small. At the same time, increases in local property taxes serve to increase production costs. Consequently, an increase, for example, in the level of property taxes in North Carolina above the level of property taxes in other areas will have little effect on agricultural product prices but will increase costs and, hence, decrease the net return to land. An increase in the tax cannot be shifted forward in the form of higher product prices under these conditions, but will be reflected in a decrease in the return to land and, hence, land price.[2]

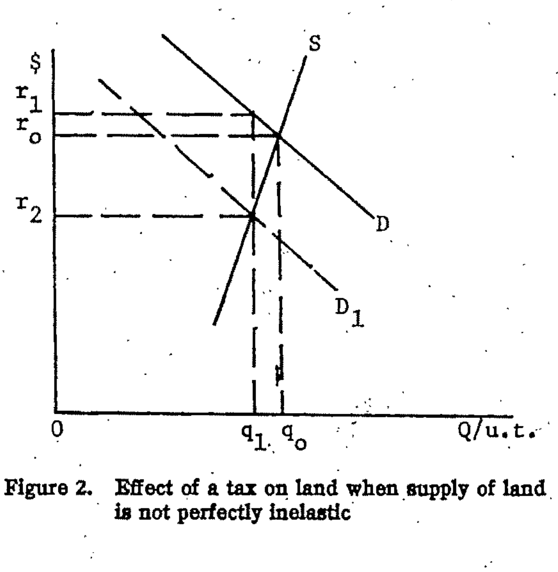

Figure 2. Effect of a tax on land when supply of land is not perfectly inelastic

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[1] Even if the supply of land and other real estate were perfectly inelastic, however, one cannot conclude that the value of the land would necessarily be reduced by the amount of the capitalized tax. The proceeds of a real property tax might be used to provide roads or other public services which increase the value of the taxed property. In this case, property taxes are likely to be less than fully capitalized into lower property values even though the supply of real estate were highly inelastic.

[2] This conclusion must be tempered, however, to the extent that the demand for agricultural real estate comes from nonagricultural uses, the price of a product is significantly affected by increases in North Carolina production

The Model

The value of farm real estate on a county basis for North Carolina is regressed on the tax rate and a group of variables expected to be associated with changes in prices of farm real estate.[3] Four categories of explanatory variables related to agricultural productivity, farm size, urban influences, and recreational demand were included in the analysis.

Observations of the present study were on a county basis for North Carolina. The dependent variable was the average value per acre of farmland and buildings. The average value of farm real estate was $318 per acre ranging from a low of $169 per acre to a high of $577 per acre [12].[4]

The effective tax rate, which is the nominal or actual rate times the assessment ratio, was used to indicate the level of property taxes. The official assessment ratio in North Carolina, i.e., the ratio of assessed value to appraised value, ranges from 40 percent to 100 percent. The average effective tax rate for all counties included in the study was $.79 per hundred dollars assessed value ranging from $.48 to $1.24 per hundred dollars assessed value between counties [5].

Three different variables were used to reflect differences in productivity. The hypothesized sign for each of the productivity variables was positive. The data source for each of the variables was the 1970 North Carolina *Agricultural Statistics* [4]. The first productivity variable, cropland as a percent of total farmland, was hypothesized to have a positive sign since cropland has a higher value, on the average, than other farmland.

Two economic measures of productivity were used. The first variable, the market value of crops and forestry per acre of land in farms, provides a measure of differences in land value due to allotted crops and soil productivity. However, differences in farm real estate values (given soils and allotted crops) might also exist due to different amounts of hogs or poultry. Hence, the second variable included the value of all agricultural products sold per acre of land in farms not included in the first variable. The two variables were not highly correlated ($r = .28$).

Size of farm was included since a number of past studies has shown that the average value of farm real estate per acre tends to decrease as farm size increases. Hence, the coefficient of the farm size variable was hypothesized to have a negative sign.

Previous studies have shown urban influence to be an important determinant of farm real estate prices, especially for farmlands located near large urban centers.[5] Two measures of economic growth or development were taken from the 1970 *Census of Population* [11]. First, population per square mile within a county provides an indication of the current level of development. Second, the percentage change in population from 1960–70 indicates the rate of economic growth. It was hypothesized that an increase in each of the variables was associated with an increase in farm real estate values.

Finally, two dummy variables were included to compensate for intangible factors related to recreational opportunities which were hypothesized to cause farm real estate values to be higher in the mountain and coastal counties of North Carolina. These variables were hypothesized to have positive signs.

In summary, the following economic model was formulated:

$$(1) \quad Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9)$$

where

Y = Average county value of farm real estate in North Carolina, per acre, 1969.
X_1 = Effective property tax rate in dollars per hundred dollars assessed value on an annual basis by county, 1969.
X_2 = Percentage change in population from 1960–70 by county in North Carolina.

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costs due to a large part of total output of the product being produced in North Carolina, or the proceeds of the tax are used to provide roads or other public services which enhance the value of the taxed property.

[3] The model is similar to that used by Hyman and Pasour [2] and Oates [7].

[4] The 14 counties comprising the six Standard Metropolitan Statistical Areas in North Carolina were excluded from the analysis due to the definition of one of the independent variables related to urban influence. These 14 counties were Brunswick, Buncombe, Cumberland, Davie, Durham, Forsyth, Guilford, Mecklenburg, New Hanover, Orange, Randolph, Union, Wake, and Yadkin. Three other counties (Dare, Cherokee, and Gaston) were excluded from the analysis since data on one or more variables for these counties were not available.

[5] The location of farmland relative to urban centers was initially included as an explanatory variable of farm real estate prices. The distance to an urban area for each of the North Carolina counties in this study was taken to be the linear distance of the county from the nearest Standard Metropolitan Statistical Area (SMSA) following the procedure of Hammill [1]. The coefficient of this variable was not significant in preliminary tests of the model, and the variable was then dropped from the analysis.

X_3 = Population per square mile by county in North Carolina, 1970.
X_4 = Cropland as a percent of total farmland by county in North Carolina, 1969.
X_5 = Average market value of crops and forestry per acre of land in farms by county in North Carolina, 1969.
X_6 = Average market value of all other agricultural products sold per acre of land in farms for each county in North Carolina, 1969.
X_7 = Average size farm by county in North Carolina, in acres, 1969.
X_8 = Dummy variable for counties located in Western North Carolina.
X_9 = Dummy variable for coastal counties in North Carolina.

All variables except X_1 and X_7 (tax rate and average size farm) were in linear form. Variables X_1 and X_7 were employed in log form which slightly increased their explanatory power.[6]

Empirical Results

The economic model specified in the previous section was estimated by ordinary least squares regression procedures using cross-sectional data. There were 83 observations.

The following equation was estimated:[7]

$$(1)\quad Y = 293.51 - \underset{(28.41)}{74.02}\log X_1 + \underset{(0.70)}{1.97}X_2 + \underset{(0.15)}{0.34}X_3 + \underset{(0.68)}{1.97}X_4 + \underset{(0.22)}{1.99}X_5 + \underset{(0.15)}{0.50}X_6 - \underset{(20.27)}{47.91}\log X_7 + \underset{(19.67)}{109.10}X_8 + \underset{(16.35)}{17.47}X_9$$

$$R^2 = .72.$$

The standard error for each of the regression coefficients is shown directly below the coefficient. The regression coefficient of each variable has the hypothesized sign, and the coefficients of all variables except for X_9 have relatively small standard errors. The variables explain approximately three-fourths of the variation in the per acre value of farm real estate between various counties of North Carolina. The relationship between the tax rate and property values is analyzed after a brief discussion of the relationship between the other independent variables and the value of farm real estate.

Relationship of non-tax variables to farm real estate values

The coefficient for each of the urban influence variables, X_2 and X_3, was positive. The coefficient for X_2 indicates that an increase of 10 percent in county population during the decade of the 1960's, other factors held constant, was associated with an increase of $19.70 per acre in the average value of farm real estate. The coefficient for population density, X_3, indicates that an increase in population of 10 persons per square mile was associated with an increase of $3.40 per acre in average value of farm real estate. Mean values of X_2 and X_3 were 2.8 and 75.4, respectively.

Each of the productivity variables has the hypothesized positive sign. An increase of 5 percent in cropland as a percent of total farmland, X_4, was associated with an increase of $9.85 per acre in the value of farm real estate. An increase of $10.00 per acre in the average annual market value of crops and forestry sold per acre of farmland, X_5, was associated with an increase of $19.90 per acre in the average value of farm real estate. An increase of $10.00 per acre in average market value of all other agricultural products sold per acre of farmland, X_6, was associated with an increase of $5.00 per acre in the average value of farm real estate. The average values of X_5 and X_6 were $47.50 and $38.00, respectively. The larger coefficient for X_5 relative to X_6 is plausible since production of crops and forestry is likely to be more closely related to land productivity than is the production of commodities which are more capital intensive, e.g., poultry and hogs.

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[6] This semi-log form means that one expects a given percentage change in an independent variable to have the same effect on the dependent variable regardless of the absolute level of the independent variable. Use of this functional form thus implies that one expects the impact of a given change in an explanatory variable on property values to be less at higher values of the variable. The value per acre of farm real estate, for example, is not likely to vary linearly with the absolute level of the tax rate. Instead, a given change in the tax rate (e.g., $.10/$100 assessed value) would likely have a smaller effect, the higher the tax rate.

Previous studies have shown that an increase in farm size is typically associated with a decrease in average price per acre of land. It is unlikely, however, that the increase is linear. It is likely that an increase in farm size of a given amount, e.g., one acre, would be associated with a smaller decrease in average land price as average farm size increases.

[7] The coefficient of log X_1, (b_1), or log X_7, (b_7), is $b_i = \partial Y/\partial x_i/X_i$. Equivalently, $\partial Y = b_i(\partial x_i/X_i)$. If the percentage change in X_i is 1 percent, then the change in Y is $.01(b_i)$. That is, the coefficient of log X_i (when divided by 100) may then be interpreted as the change in the absolute value of Y associated with a 1 percent change in X_i.

Average size farm, X_7, was inversely related to average value of farm real estate on a per acre basis when other factors were taken as constant. The coefficient for X_7 indicates that a 10 percent increase (decrease) in average farm size was associated with a decrease (increase) of $4.79 per acre in the average value of farm real estate. Demand for residential purposes and for add-on land to farms may explain part of the reason for the inverse relationship between size of farm and real estate values on a per acre basis. A more plausible explanation, however, may be that the ratio of the value of improvements to land including dwellings is higher for smaller farms.

The dummy variables, X_8 and X_9, were included to compensate for intangible factors related to recreational opportunities which were hypothesized to cause farm real estate values to be higher in mountainous and coastal areas of North Carolina. The significant coefficient for X_8 indicates that average farm real estate prices are approximately $110 per acre higher in Western North Carolina after adjusting for farm size, economic productivity, agricultural tax rate, and the other variables included in equation (1). The coefficient for X_9 has a large standard error. This is not too surprising since much of the agricultural land in the coastal counties is not well situated for recreational uses.[8]

Capitalization of property taxes

The statistically significant coefficient of the tax rate variable, X_1, indicates that an increase of 10 percent in the effective property tax rate was associated with a decrease of $7.40 per acre in the average value of farm real estate. This means that an increase in the effective local property tax rate from $1.00 to $1.10 per $100 assessed valuation will reduce the market value of farm real estate by about $7.40 per acre.[9] This result suggests that long-run capitalization of property tax differentials on farm real estate in North Carolina does occur, but this result by itself does not indicate the extent of capitalization.

How does the capitalization suggested in (1) compare with full capitalization of an increase in the effective tax rate from $1.00 to $1.10 per $100 assessed valuation? Consider the average value of farm real estate in the sample with a market value (V) of $318 per acre and assume that the appropriate discount rate for land is 5 percent. How would full capitalization affect market value under these conditions?

At an interest rate of 5 percent and a tax rate of 1 percent, land must yield an annual return of $19.08 to be consistent with the market value of $318 per acre. That is, $\$318 = R/.05 + .01$ or $R = \$19.08$.

If the tax rate increases to 1.1 percent (from $1.00 to $1.10 per $100 assessed valuation) and the annual return is $19.08 per acre, market value is reduced to $312.79: $V = 19.08/.05 + .011 = \$312.79$.

Full capitalization of the increase in tax rate reduces the market value of farm real estate by slightly more than $5 per acre. The empirical results obtained in the analysis as presented above in relationship (1) thus would appear to suggest that property tax differentials are more than fully capitalized. However, the discount rate used in the capitalization procedure is the critical variable in determining the extent of capitalization on property values. The higher the discount rate, the smaller the capitalization effect of a given change in the tax rate (assuming full capitalization). For example, if a discount rate of 7 percent (instead of 5 percent) is used in the above example of a 1 percent increase in the effective tax rate, full capitalization of the tax differential implies a reduction in value of only $4 (from $318 to $314).

The rapidly appreciating value of farm real estate must be taken into account in determining the appropriate discount rate to use in the capitalization procedure. The index value

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[8] The Tiebout hypothesis was also tested in the analysis [9]. This hypothesis holds that property owners (and other consumers) shop among communities with different packages of local public services to select the community offering the combination of taxes and expenditures most closely suited to their preference.

Local schooling is the major public service provided to owners of farm real estate. The Tiebout hypothesis was tested in two other versions of the model by including alternative measures of educational expenditures (as measures of public output). The first regression included educational expenditure on a per capita basis while the second included these expenditures on a per pupil basis [6]. In each case, the coefficient of the public output variable was nonsignificant. The nonsignificant coefficient of the output variable (in both equations) does not support the Tiebout hypothesis as it relates to farm real estate in North Carolina. This result is not surprising in view of mobility obstacles for farmers. These obstacles are likely to swamp the impact of public output in the farmer's location decision.

[9] The increase in effective tax rate from $1.00 to $1.10 represents an increase of .10 of one unit in X_1 expressed in natural log form.

(1967 = 100) of average value per acre of farm real estate in North Carolina increased from 40 in 1950 to 122 in 1971 [13, p. 47]. This indicates that the average nominal value per acre of farm real estate in North Carolina has more than tripled since 1950 and represents a compounded rate of appreciation of average farmland values on a per acre basis of slightly more than 5 percent per year.[10]

Since this increase in farm real estate values has persisted over a long period of time, one might expect the appreciation to be reflected in prices of farmland. In this case the capitalization formula for estimating value of farm real estate should reflect the annual rent or return on land, the tax rate, and the rate of appreciation. Modifying the capitalization formula slightly to reflect the return due to appreciation in farm real estate values results in the following: $V = R - tv + AV/i$.

where

V = Market value per acre of land.
R = Annual land rent per acre with the rent assumed to be received in perpetuity.
t = Effective tax rate (on a percentage basis).
i = Discount rate.
A = The expected annual appreciation in farm real estate values (on a percentage basis).

Solving for V gives $V = R/i + t - A$.

Assume for a moment that the effective tax rate is zero. If i is the market interest rate, e.g., 8 percent, and land is expected to continue to appreciate at 5 percent per year, the appropriate discount rate in capitalizing the annual rent on the land would be 3 percent instead of 8 percent.

How is the average value of farm real estate in North Carolina in this study ($318/acre) affected by full capitalization of the increase in effective tax from $1.00 to $1.10 when the discount rate is 3 percent? In this case, full capitalization implies a reduction in value to $310 per acre, or a decrease of $8 per acre.[11] Consider another example. Full capitalization implies a $10 per acre reduction in value at a discount rate of 2 percent. A 2 percent discount rate would be appropriate if the market interest rate were 7 percent and the expected rate of appreciation in land values were 5 percent per year. Hence, the results presented in (1) indicate that an increase (decrease) in property taxes on farm real estate in North Carolina is substantially capitalized in the form of depressed (increased) property values.

Implications

The empirical results discussed above indicate the extent to which property tax differentials (not total property tax levies) are capitalized. Strictly speaking, the results of this study do not indicate the impact on property values of that portion of property taxes which is common to all taxing jurisdictions (counties) included in the analysis.[12] A similar relationship may hold between a change in the level of farm real estate taxes in North Carolina *vis-à-vis* those in other states for the reason cited above, *viz.*, changes in local property taxes affect costs but have little effect on agricultural product prices which are largely determined in a national market. There is no consensus concerning the incidence of that portion of property taxes levied on farm real estate which is common to all states.

A number of proposals have been advanced to reduce the dependence of local governments on local property taxes. However, there is little information concerning the distributional impact of many of the proposals. For example, how would a decrease in local property taxes affect owners of farm real estate *vis-à-vis* other property owners? The answer to this question is necessary in analyzing the effect of moving to a frequently discussed system in which the state assumes increased responsibility for the financing of local schools.

Consider the often cited proposal to eliminate the use of local property taxes in supporting local schools. In 1969–70 about 40 percent of all property taxes levied by all local jurisdictions in North Carolina were levied in support of public schools [5, p. 282].[13] What would be the effect of a 40 percent reduction in the property tax rate for owners of farm real estate relative to residential home owners in North Carolina? If it is assumed that the results obtained in (1) apply to the full amount of the reduction, an estimate of the effect on farm real estate values can be obtained. The average county value of farm real estate in North Carolina was \$318 per acre, and the average effective tax rate was \$.79 per \$100 assessed valuation (for the 83 counties included in the analysis). The average property tax actually levied per acre of farm real estate in North Carolina in 1970 was \$1.79 [14]. This implies that the average appraised value was \$227 per acre (when the average effective tax rate was \$.79). The average size farm was 121 acres (for the 83 observations included in the analysis) so that the average property tax bill was \$217 (121×\$1.79).

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[10] Compounded rates of appreciation of average farm real estate values per acre in North Carolina during the past 30, 40, and 50 year periods were approximately 6.5, 5.0, and 3.5 percent, respectively [13, p. 47].

[11] $\$318 = R/.03 + .01$ or $R = \$12.72$.
$V = 12.72/.03 + .011$ or $V = \$310$.

[12] This is basically the same problem or limitation one faces in interpreting any empirical result, *viz.*, one cannot extrapolate beyond the range of the data.

[13] This figure is considerably below the U. S. average since the state already provides about 70 percent of the operating expenses of local schools in North Carolina.

A 40 percent reduction in the effective property tax rate to \$.47 [using relationship (1)] to capitalize the decrease in taxes would increase property values by \$38 (from \$318 to \$356) per acre and reduce property taxes from \$1.79 to \$1.19 (\$.47×2.53) per acre (from \$217 to \$144 per farm).[14] This amounts to a reduction in taxes paid of 34 percent. Hence, a given reduction in the effective tax rate under these conditions will reduce the amount of property taxes paid by less than the reduction in the tax rate.[15]

This result when considered in connection with results of a closely related study recently completed in North Carolina concerning the relationship between real property taxes and residential housing values suggests that property tax reduction considered alone may yield a differential impact on farmers versus other groups of taxpayers.[16] The closely related study indicates that changes in property taxes have little effect on the value of residential housing in North Carolina [2].[17] If this is correct, a 40 percent decrease in the property tax rate would decrease the amount of property taxes paid by approximately 40 percent for owners of residential housing. Hence, owners of farm real estate would receive a smaller tax benefit for a given reduction in the property tax rate per \$100 of taxable real estate to the extent that there is more capitalization of property taxes into higher farm real estate values.

The full impact of a change in the effective property tax rate for farmers relative to nonfarmers, however, hinges on the level of the tax rate, the extent to which property taxes are capitalized, and on the amount of property being taxed. The effective tax rate for farm real estate is lower, and there is evidence that farm real estate is appraised at a lower rate (relative to market value). However, average market value of farm real estate owned per farmer appears to be higher than the average value of real estate owned by the average nonfarmer.

How does the total effect of a 40 percent decrease in the effective property tax rate for farm real estate compare with the effect of a similar decrease in the effective tax rate for residential housing? A recent study (alluded to above) of the relationship between real property taxes and residential property values in North Carolina for towns exceeding 2,500 in population found that the average effective tax rate was \$1.53 per \$100 assessed valuation and the average market value of owner-occupied houses was \$12,500 [2]. If this real estate were appraised at market value, the average tax bill would be \$191. Residential real estate in North Carolina on the average, however, appears to be appraised about 19 percent below market value.[18] This reduces the average tax bill from \$191 to \$155. A 40 percent reduction in property taxes is then equivalent to a reduction in taxes of $62. This compares with a $73 reduction in the amount of property taxes per farm (from $217 to $144) as computed above. Thus, the net effect of a given percentage reduction in property taxes on the average appears to be larger in absolute amount for North Carolina owners of farm real estate in spite of a lower tax rate and the capitalization effect because the average value of real estate held by farmers is considerably higher.[19]

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[14] A decrease from \$.79 to \$.47 is equivalent to a decrease of .52 unit of the natural log of the effective tax rate. The appraised value after the decrease in tax rate is assumed to represent the same proportion of the market value as prevailed before the tax reduction, *viz.*, .71. This suggests that farm real estate on the average is appraised about 30 percent below market value.

[15] There is, however, an added capital gain to the owner of real estate whose value is enhanced as a result of a reduction in the rate of taxation of real property. The conclusion that a given percentage reduction in the tax rate will reduce property tax payments by a smaller percentage assumes an adjustment period sufficiently long for property to be reappraised in response to the increase in value arising from the decrease in tax rate. Taxes would fall in proportion to the change in the tax rate until reappraisal occurs.

[16] The method of providing additional state tax revenue (sales taxes, income taxes, etc.) to compensate for the reduction in property taxes is also likely to have a differential impact on farmers *vis-à-vis* other groups of taxpayers.

[17] This work indicates that increases in taxes on both owner-occupied and rental property are largely passed on in the form of higher rents (implicit rents for owner-occupied property). The long-run and short-run effects of a decrease in the tax rate may be quite different. An adjustment period is assumed which is sufficiently long for the stock of housing to respond to the initial increase in value of housing brought about by the decrease in tax rate.

[18] The average county ratio of assessed value to appraised value at the time of the study was 55. The percentage ratio of assessed value to sales price of tracts of residential property actually sold in North Carolina in 1966 was 44.6 [10, pp. 42–47]. This implies that the appraised value of residential real estate on the average was 19 percent below the market value.

This does not mean, of course, that a given decrease in the effective property tax rate would benefit all farmers more (relative to nonfarmers). The larger the value of real estate held, the greater the benefit from a given reduction in the tax rate. Thus many owners of above average homes would benefit more from a given reduction in the effective property tax rate relative to many small farmers owning less than the average amount of farm real estate.

Conclusions

The results of this study are consistent with the widely held hypothesis that property taxes levied on land are largely capitalized into lower land prices. The results also emphasize that the effects of "property tax relief" for farmers will be quite different depending on the size of farm and the extent of capitalization of property taxes levied on farm property *vis-à-vis* other forms of real estate.

Property taxes are much less important in financing local governments in North Carolina relative to most states. Consequently, the potential distributional effects of "property tax relief" may be greater in other states. However, property taxes are of major importance to farmers throughout the U. S. In view of these factors, it is surprising that agricultural economists have not devoted more attention to the relationship between property taxes and farm real estate values. Information on this relationship is required to assess the effects of specific policy alternatives including the substitution of sales or income taxes for real property taxes or preferential taxation of agricultural land.

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[19] Equipment and personal property are excluded from both estimates. It is likely that the value of this kind of property is higher for farmers on the average relative to nonfarmers. Data to make this comparison are not available.

The aggregate effect of a given decrease in the tax rate for farm vs. nonfarm real estate owners depends on the proportion of farm real estate in the tax base. The aggregate value of farm real estate in North Carolina in 1969 was about four billion dollars [12]. This was estimated to be slightly less than one-fourth of the total value of real property [5]. Thus the aggregate impact of a given tax reduction on real property for farm real estate would be much less than the impact for other real estate. For policy purposes, however, the incidence of a tax reduction for farmers as individuals *vis-à-vis* individuals of other groups is more important than the aggregate effect.

References

[1] Hammill, A. E., "Variables Related to Farm Real Estate Values in Minnesota Counties," *Agr. Econ. Res.* 21:45–50, April 1969.

[2] Hyman, D. N., and E. C. Pasour, Jr., "Real Property Taxes, Local Public Services, and Residential Property Values," *Southern Econ. J.* 29:601–611, April 1973.

[3] Netzer, Dick, *Economics of the Property Tax*, Washington, D. C., The Brookings Institution, 1966.

[4] North Carolina Department of Agriculture, *North Carolina Agricultural Statistics, 1970*, No. 122, Raleigh, N. C., Federal-State Crop Reporting Service, 1971.

[5] North Carolina Department of Tax Research, *Statistics of Taxation*, Raleigh, N. C., Biennial Report of the Department of Tax Research, 1970.

[6] North Carolina State Board of Education, *1969–1970 Current Expenditures by Source of Funds*, Raleigh, N. C., 1971.

[7] Oates, Wallace E., "The Effects of Property Taxes and Local Public Spending on Property Values: An Empirical Study of Tax Capitalization and the Tiebout Hypothesis," *J. Political Econ.* 77:957–971, Nov.–Dec. 1969.

[8] Schuh, G. E., and W. C. Scharlach, *Quantitative Analysis of Some Farm and Nonfarm Determinants of Agricultural Land Values: Impact of Economic Development*, Indiana, Agr. Exp. Sta. Res. Bull. 821, 1966.

[9] Tiebout, C., "A Pure Theory of Local Expenditures," *J. Political Econ.* 64:416–424, Oct. 1956.

[10] U. S. Bureau of the Census, *Census of Governments, 1967*, Vol. 2, *Taxable Property Values*, Washington, 1968.

[11] ———, *Census of Population, 1970, Number of Inhabitants*, Final Report PC(1)-A35: North Carolina, Washington, 1971.

[12] ———, *1969 Census of Agriculture*, Vol. 1, *Area Reports*, Part 26, Sections 1 and 2, County Data: North Carolina, Washington, 1972.

[13] U. S. Department of Agriculture, *Farm Real Estate Market Developments*, ERS CD76, 1971.

[14] ———, *Farm Real Estate Taxes, Recent Trends and Developments*, ERS RET-12, 1973.

Allocation of Scarce Resources to Agricultural Research: Review of Methodology*

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With an increasing stress on research budgets, the impetus for investigation of alternative models for managing research is growing. Much work has been invested already in technique development. To precede additional research, the current state-of-the-art in resource allocation methodology pertinent to agricultural research management is presented. The focus is on quantitative approaches for improving internal consistency of subjective judgments. The marginal principle is applicable to the selection of an optimal investment in management, and a rudimentary framework for implementing that principle is suggested.

AGRICULTURAL research projects are often selected and funded by diffuse decision processes. This paper intends to contrast them to formal structured processes in order to introduce agricultural economists to the breadth of research conducted on research management and to stimulate thought for further research. The current state-of-the-art of research on research project selection and resource allocation is presented through a survey of the extant literature and recent unpublished studies. A practical approach for utilizing the marginal principle to select the optimum investment in management is outlined also.

The procedures surveyed take the individual's subjective judgments as given and help give internal consistency in ranking research efforts and in allocating resources to them. They do not assist directly in formulating the "correct" judgment about a particular effort, although some stimulate opinion changes with additional information.

Overview to the Problem

Current decision process

The great bulk of agricultural research conducted in the United States is performed by public organizations, primarily the U. S. Department of Agriculture and the State Agricultural Experiment Stations. While the decision process for allocating resources among research efforts varies considerably between organizations, the following approach has been reasonably typical.[1] The management system consists of the administrative officer, department heads, and professional scientists. In the project funding process the administrative officer judges project outlines submitted to him by department heads who previously analyzed proposals prepared by a larger number of scientists, most of whom have tenure. Decisions about individual projects are largely made on a year-to-year basis by each scientist acting as an entrepreneur on behalf of his own professional life; if he chooses projects which are not rewarding to the funders, other scientists, and the administration, then he suffers. A great weight is placed on him for selection of the appropriate projects. The decision function involves not the selection and funding of specific projects so much as it is the employment of specific scientists who will be attached to the research organization for a considerable period. Emphasis is on maximum freedom for the scientist to select projects and undertake desired research with minimum control or direction from administrators. Furthermore, if experiment station administrators are not willing to support specific research, the scientist there is normally free to seek grant funds from outside sources.

Why modified decision processes are of interest

Soon after World War II, as public investment in research began a two-decade period of rapid growth, investigations of alternative approaches to manage research were reported for the first time. Stimulus for such work came primarily from corporate managers concerned

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[1] My thanks are due to Dale Hoover for his clear articulation of this process. While the terminology is for a State Experiment Station, the essential features are not greatly dissimilar from many USDA research agencies.

with the rate of return from investments in research as opposed to other activities and from government funders anxious to prevent waste from the rapidly growing budget. Since the availability of scientists was lagging behind, it was a seller's market. Researchers had little difficulty securing funds for interesting problems.

In recent years, however, the cycle has peaked and the supply-demand relationship changed. Federal research and development expenditures have leveled off and substantial decreases have occurred in several areas, including atomic energy and space [21 (1968) p. 526; (1969) p. 524; (1971) p. 510; (1972) p. 522]. Nonfederal expenditures have continued to rise, but not enough to offset even the effects of inflation [21 (1971) p. 508]. With greater competition among scientists for available funds, internal pressures have recently surfaced for more intensive investigation of management processes.

Attention is focusing more directly on the research administrator, an important link between funding sources and scientists. It is he who must account for current expenditures of funds while assuring significant achievements over time from a highly uncertain production process; he must allocate support funds even though he cannot program breakthroughs; he must keep scientists' morale high and give them sufficient latitude to perform at their best at the same time they are competing more strenuously for limited resources. Or, he can solve the increased competition problem simply by allocating support funds evenly among all researchers or in proportion to salary. He can also reduce the size of his research staff through attrition and/or termination of untenured or noncareer scientists. He or his designates can evaluate the merits of the research proposals and specify which will be funded and how much. Here he will find an impressive array of management techniques generated in recent years, the objective of which is to help him be internally consistent and/or increase his likelihood of receiving essential information to formulate a valid judgment.

Most of the management tools presented in the next section are taken from the research management, utility theory, and behavioral science literatures. A few are taken directly from agricultural literature. These techniques vary widely in amount of time required to implement them, processing costs incurred, and information generated. Important questions selectively addressed in this paper include:

1. How quickly can judgments be obtained via the technique?
2. What processing costs are incurred?
3. How many opinions are listened to?
4. How does the technique affect the risk of a bad decision?
5. What types of information can be obtained from the process (i.e., ordinal or cardinal ranking of projects, benefit/cost ranking, recommended allocation, summaries of specified characteristics)?
6. How does the process handle funding options, multiple constraints, and uncertainties?
7. How many techniques is it compatible with?
8. How have users judged the value of its products?

Project Ranking

Methods of ranking projects using both single and multi-dimensional measures of project benefit will be introduced first.

One-dimensional ranking methods

Individual participant "comparative" methods.—Several techniques, including Q-sort, paired comparisons, successive ratings, and successive comparisons, are included in this category.[2] Each has the common characteristic that a single judge compares the overall subjective worth of one item to another or group of items. When only a few items must be evaluated, methods in this group are among the simplest procedures for systematic comparison. An implicit assumption is that each item is independent and mutually exclusive of all others.

With Q-sort, projects are divided into hierarchal categories on the basis of their expected benefits.[3] Typically, essential information about a project is written on a card and the cards are then sorted into piles. No quantitative values are assigned to any category, but each may be divided into additional categories until no significant differences in anticipated benefits are discernible among its projects.

With paired comparisons, a complete ordering of projects is obtained and verified. All possible pairs are compared and the one with the higher expected benefit identified. Again, no quantitative value is assigned to any project—only an ordinal ranking.

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[2] Basic references for these techniques include Guilford [12], Luce and Raiffa [13], and Churchman, Ackoff, and Arnoff [8].

[3] This can be done on any other standard basis.

After projects are ordinally ranked, successive ratings and/or successive comparisons can be applied to establish and verify a relative cardinal ranking. Benefit-cost ratios can be computed from these rankings and used as a rational method of allocation if the funding decision is strictly of the "go-no go" type.

With successive ratings, an arbitrary base number is assigned to the highest-ranked project. Numbers are given to each subsequent project in accordance with its anticipated benefits relative to the top one. These values are verified by covering them and repeating the comparison relative to the lowest-ranked project. If significant differences appear in the two sets of numbers, the procedure is repeated until consistent ratings are obtained when the scale is anchored to both the highest and lowest-benefit projects.

With successive comparisons, initially assigned values are refined by comparing the value of one high-benefit project to portfolios of lower-benefit ones. The number of projects in the portfolio is successively reduced until the single high-benefit project is preferred to the portfolio. The logic of this method is structured to establish bounds on the cardinal ranks of all projects and to identify inconsistencies in earlier assigned values.

A final comparative approach, dollar metric (see [19]), permits the calculation of absolute benefit-cost ratios. Paired comparisons are used first to identify the preferred project from each possible pair. From an estimate of the expected cost of each project, the participant specifies how much the cost of the preferred project could increase before the other would be chosen. He repeats this procedure for all pairs. Next, he determines how much the cost of the least preferred project could increase (or decrease) before he would be indifferent between funding the project or not having a project in this research area. This base figure permits the specification of anticipated benefit in dollar terms. By identifying actual expected cost, he can calculate a benefit-cost ratio with the numerator and denominator in the same units.

Features of the comparative ranking methods are summarized in Table 1. Also included are two rankings of the methods by ease of use and user satisfaction with the product of the method. Rankings of the methods are based upon the reactions of middle managers who used four of them during a workshop on benefit measurement. Those methods which were easier, faster, and more natural to use also resulted in project rankings which were less useful and/or less satisfactory to the person applying them. Several expressed most satisfaction with the ranking generated by using successive comparisons. However, each concluded that the thought process of comparing a proj-

Table 1. Comparative ranking methods[a]

Ranking method	Type of rank obtained	Potential uses in research evaluation	Ranking methods it can be used with	User satisfaction with ranking	Ease of use
Q-sort	Categories	Grouping of projects, program areas, criteria, or objectives	All	4	1
Paired comparisons	Ordinal	Ranking of projects, program areas, criteria, or objectives	*Q*-sort, dollar metric, group methods, multi-dimensional methods	3	2
Successive ratings	Cardinal—relative scale	Ranking of projects, program areas, criteria, or objectives	*Q*-sort, paired comparisons, successive comparisons, group and multi-dimensional methods	2	3
Successive comparisons	Cardinal—relative scale	Ranking of projects, program areas, criteria, or objectives	Successive ratings, group and multi-dimensional methods	1	4
Dollar metric	Cardinal—absolute scale	Ranking of projects, program areas, criteria, or objectives	*Q*-sort, paired comparisons, group and multi-dimensional methods	NA	NA

[a] Ordering of methods is based upon author's experience in working with 20 middle managers who applied the methods in a large governmental research and development organization. 1=highest ranked method (most satisfaction or easiest). NA=not applied.

ect to portfolios was unnatural and preferred successive ratings even with a slightly less satisfactory ranking.

Group-determined measures of benefit.—Even after the individual's subjective rankings are elicited, the problem remains concerning which person(s) to listen to and how to process multiple opinions. A number of options are open. The decision-maker can identify one "best" judge and listen exclusively to him. Alternatively, to increase the likelihood of obtaining a more nearly "correct" opinion, he can identify several experts and accept a simple or weighted average of their opinions as the best estimate. Following this course also permits determination of the degree of variance among their opinions, an important byproduct. A third course permits interaction between participants. However, when that occurs, independence of opinion is partially muted, and the ability to use statistical measures of variance is restricted. There are several forms of group interaction:

1. In the "committee or round table" apapproach, the group meets together, airs differences of opinion, and concludes with a reportedly "group opinion." Minority opinions may also be expressed.

2. In the "chain-of-command" approach, interaction takes place between adjacent links. If a superior disagrees with a subordinate's opinion, the subordinate's view may be totally suppressed in the next step when the superior interacts with his superior. Most typically, only a single opinion exits from the highest link in the chain, and that is often formed through interaction with one other person. That individual in turn presented only one opinion although a wide variety may have surfaced in the interaction that preceded it. A variant of this approach, in which panels are included as three links in the chain, is being used at the Iowa Agricultural Experiment Station to evaluate five-year research alternatives [11, pp. 326–343].

3. One formal methodology designed to promote consensus of opinion without obscuring variants is known as Delphi [9]. It consists of a series of individual interrogations to a group of experts, interspersed with information and opinion feedback. Some questions inquire into reasons for previously expressed opinions. A collection of such reasons is then presented to each respondent with an invitation to reconsider his earlier estimate. Delphi attempts to improve the committee approach by subjecting views of individual experts to each other's criticism in ways that avoid face-to-face confrontation. It provides anonymity of opinions and of arguments advanced in their defense.

Each of the group methods can be used to obtain ordinal or cardinal rankings of projects, program areas, criteria, or research objectives. They can be used singly or in conjunction with comparative and/or multi-dimensional methods. However, while several of the comparative methods make a logical system when used in succession, few of the group methods do. The methods are ranked by the author relative to three criteria in Table 2. As with the comparative methods, none is consistently high or low with respect to all criteria. The one which requires the least time from all judges combined also permits the fastest rendering of a final judgment because only one person need be involved, but it results in the highest risk of a "bad" judgment being made. In addition, measures of variant opinions are normally restricted to the group average and Delphi methods. And, although opinion variation can be calculated at each round of Delphi, a statistical measure of variance satisfies the independency of observation requirement only in the first round.

Multi-dimensional ranking methods

Information systems.—Their basic objective is to provide important information to the administrator in a form which will assist him in choosing among decision options. No attempt is made to place projects in overall rank order, but measurements for each dimension of benefit are listed. Several information systems have been designed for research project evaluation and one specifically for a state experiment station (Fishel [11]). In Fishel's system, scientists provide subjective judgments for each proposed project. They estimate average annual expenditures, time requirements, and technological feasibility of attaining a research product. Expected value of the research product is defined in dollars. Subjective probability distributions of cost and value are generated for alternative levels of annual expenditure by a Monte Carlo sampling procedure. The system provides estimates of the benefit/cost ratio, standard deviation in that ratio based upon variant opinions, a technical feasibility index, and the number of years of effort required at alternative rates of funding. Since basic independence is assumed between projects, the

Table 2. Group ranking methods[a]

Group method	Type of rank obtained	Potential uses in research evaluation	Ranking methods it can be used with	Theoretical risk of "bad" judgment	Total time required of all judges	Speed of obtaining judgment	Estimate of variance among judges possible?	Special problem areas
"Best" judge	Flexible-categories, ordinal, and/or cardinal	Ranking of projects, program areas, criteria, and/or objectives	Comparative and multi-dimensional methods	5	1	1	No	How to identify "best" judge?
Group average			Same as above	3	2	3	Yes	
Committee			Same as above	2	3	4	Not usually	Most respected or persuasive member's opinion likely to carry excessive weight
Chain of command			Committee, comparative and multi-dimensional methods	4	2	2	Not usually	Subordinate opinions are subdued in subsequent interactions
Delphi			Comparative and multidimensional methods	1	3	5	Yes	

[a] Ordering of methods is author's evaluation. 1=highest ranked method (least risk, least time requirements, fastest judgment).

presence and magnitude of interdependencies must be assessed by the administrator. He must also specify the relative importance of each dimension of benefit in order to develop an overall ranking of projects.

Scoring models.—A ranking approach which formally incorporates the decision-maker's subjective trade-offs and decision criteria into the model framework is known as a scoring model. A primary assumption is that a few criteria can be established which, when properly related, will specify the desirability of a decision alternative. The set can consist of both quantitative and qualitative criteria so long as each is independent of the others.

A discrete scale is developed for each criterion with sufficient range to include all projects for which an evaluation is desired and only enough categories to discriminate between projects which differ significantly relative to the criterion. Also, decision criteria can be incorporated to reject automatically or segregate for separate evaluation a project which falls outside the acceptable range for any criterion.

An overall project score is calculated generally by summing the product of criteria weights and scores over all criteria.[4] By displaying the score of the project relative to each criterion, the model doubles as an information system. This diagnostic property permits identification of weak areas in the project and encourages consideration of alternative approaches.

A comprehensive theoretical analysis of scoring model design for project ranking has been reported by Moore and Baker [14, 15]. Others have constructed working models for evaluation of research, including several in the agricultural field.

One was developed by the study team for "A National Program of Research for Agriculture" [1]. It was never used to establish priorities among research areas because of a lack of confidence in the overall scores that it generated. The team concluded that further refinement of the procedure was needed. One problem appears to have been excessive interdependence among the criteria.

Three scoring models were recently developed by administrators in the USDA Agricultural Research Service for evaluation of the agency's livestock research.[5] Building upon the experiences of the National Program of Research for Agricultural study team, they made a concerted

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[4] Some suggested scoring models calculate overall project scores by multiplication rather than by summing criterion-specific scores (e.g., see Mottley and Newton [16]). Multiplication is most appropriate if balance is paramount, if high performance relative to one criterion is of little value unless accompanied by comparable scores on all other criteria.

[5] Steven King and Ernest Corley designed and implemented the USDA models.

Table 3. Multi-dimensional ranking methods

Ranking method	Type of rank obtained	Potential uses in research evaluation	Ranking methods it can be used with	Special properties
Experiment Station information system	Partial cardinal orderings	Quantitative attribute display of projects	Comparative and/or group	
Scoring model	Overall cardinal ordering	Ranking of projects, program areas, and/or objectives	Comparative and/or group	Includes diagnostic property for identifying area(s) where project is weakest
Benefit contribution model	Overall cardinal ordering	Ranking and funding of projects and/or program areas	Comparative and/or group	Ranking may be conditional upon an assumed pattern of funding

effort to overcome the problem of interdependence among criteria. The models were implemented by three panels, consisting of 20 participants, who ranked all livestock research activities, ongoing projects, and proposed new starts. The priorities they established were used by the administration as a guide for allocating resources.

A set of scoring models is currently being applied as part of a comprehensive evaluation of ongoing and proposed research conducted by the North Carolina Agricultural Experiment Station.[6] The models have been used by panels of department heads, outside consultants, and scientists to rank proposed research by problem area groupings. Separate models were designed for major discipline areas. It is planned that the priorities established will be used to delineate major research thrusts for the next five years.

Benefit contribution models.—This approach is similar to the scoring model in that several factors are specified by which the expected merits of a decision alternative are judged. However, instead of specifying general evaluation criteria, overall goals of the organization are divided into independent, mutually exclusive objectives. The relative importance of such objectives and the contribution of a project to each of them are estimated. Total benefit of a project may be computed by product summation.

Considerable flexibility for evaluating project interrelationships is permitted. For example, the structural relationship between projects and objectives may be defined such that the contribution of one project is a function of which others are also funded. In this case it is not possible to obtain a simple ordering of benefits or benefit-cost ratios without specifying the funding level of interrelated projects. See Nutt [17] and Dean and Hauser [10] for applications of benefit contribution models to resource allocation among defense research and development efforts.

A summary comparison of the multi-dimensional ranking methods is included in Table 3. Scoring models have been used more than the others for ranking research projects. However, partial-ordering information systems analogous to the experiment station system have also been used in an informal way.

All the multi-dimensional methods are compatible for use in combination with comparative and group methods; however, the combinations vary. For example, partial orderings provided by an information system may be used as input data for obtaining an overall ordering via the comparative and/or group methods. However, with scoring and benefit contribution models, other methods are used to weight the scoring criteria or research objectives, and the overall ranking is determined by the multi-dimensional model.

Approaches for Optimizing Resource Allocation

Benefit-cost analysis

Benefit-cost ratios are frequently used as a basis for maximizing expected benefit from a given investment. To use these ratios exclusively, there must be only one constraint on resources (e.g., total research budget for one period) and only one positive funding option for each project. The decision consists merely of funding the highest ranked projects until funds are exhausted. Problems may arise because of project indivisibilities (i.e., when there is money left but not enough to fund the project next in order), but a satisfactory solution can generally be obtained by a manual check of nearby altertives. However, when there are multiple constraints, time periods, and/or project funding options, simply allocating funds based upon magnitude of the benefit-cost ratio is not so appealing.

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[6] The North Carolina models were developed by J. C. Williamson, Director, and Ralph McCracken, formerly Associate Director, of the Experiment Station.

Optimization models specifically for research

A number of specific optimization models have been developed for resource allocation in research and development when one or more of the above complicating factors exist. Some have been designed for research evaluation, but many are appropriate only for development projects. Each purports to analyze quantified subjective data in a prespecified manner and to suggest the most appropriate allocation of available resources, given the model assumptions. They vary greatly in scope and procedure. Virtually all focus on the allocation of funds and some address the issues of manpower and facility allocation as well. Some are deterministic models; others incorporate stochastic elements. Most are static; a few are dynamic. Some are constrained in focus to economic evaluations; others are unrestricted as to type of variables considered. A few attempt to derive the optimal research budget, but most treat the research budget as an upper restraint on the decision problem. For detailed references see the review articles by Baker and Pound [4], Cetron, Martino, and Roepcke [7], and Baker and Freeland [3], and the dissertation by Cartwright [6]. No allocation model developed specifically for agricultural research allocation has been reported.[7]

Since a large number of models have been described in the above references, this discussion will focus on two recent models representing different approaches to the allocation problem. Both include operational computerized models for allocating money to research projects. The first was developed for and has reportedly been implemented by an industrial research organization. The second model was developed for a defense research and development organization and is currently being used there experimentally. Both are being applied primarily to *applied* research evaluation.

Simulation.—Atkinson and Bobis [2], authors of the first model, seek to attain maximum expected profit through optimal allocation of a fixed five-year research budget among projects and over time. The approach is dynamic in that it solves for the distribution of funds among the five years. It incorporates stochastic elements, measures costs and benefits in economic units only, and utilizes a simulation procedure to obtain solutions. Expected economic value of a research product is computed as a function of the year the project is completed and the probability of technical, legal, engineering, and commercial success. Year of completion is a stochastic function of project funding in that and each previous year. The selection of projects, optimal rate of funding, and annual allocation of the total research budget are determined through an iterative procedure using only point estimates of potential payoff. The point estimates are subsequently replaced with distributions and randomly sampled by simulation to estimate the range in payoff possible from the selected strategy.

Network model.—The second model, by Baker *et al.* [5], is both static and deterministic, but it incorporates noneconomic as well as economic variables and permits direct interaction between decision maker and computer. An optimal allocation of a single-period research budget is sought through the use of a network program. Separable programming can also be used. A piecewise-linear benefit function approximates the nonlinear function. It is maximized subject to a set of budgetary constraints. The benefit function is completely flexible as to type of variable considered, with alternative forms under experimentation including a scoring model and a comparative method. The constraint set includes an upper limit on total budget and upper and lower constraints on funding of individual projects, program areas, technologies, and performing organizations. Interactive opportunities are built into the program to permit the participant to conduct sensitivity analyses by varying data inputs which are least certain and by asking "what if" type questions.

The simulation and network models represent different philosophical and mathematical approaches to allocation. Being designed for an industrial laboratory where economic profit is the motivating force, the simulation model is comprehensive in the types of market decision variables incorporated. Both stochastic variables and dynamic allocation decisions are considered. The network model was prepared for a government research and development organization where nonmarket goals are at least as important as economic ones. The budgeting process earmarks some funds for specific types of research; therefore multiple constraints must be considered. The model is static and the variables deterministic although stochastic elements can be evaluated through interaction.

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[7] Two partially developed models have been presented. The algebra for an agricultural experiment station allocation model has been discussed by Paulson and Kaldor [18]. However, the specific structure of the model and method of solution has not been discussed. The mathematical structure for a fund and manpower allocation problem in a university department has been identified by Cartwright [6]. The complexity of the problem resulted in its being left in conceptual form.

In another respect both models represent a similar view of resource allocation among research efforts. A project can be expanded or reduced in scope, and progress can be speeded up or slowed down dependent upon the resources allocated to it. Significant uncertainties exist about cost and potential payoff from any given effort. Both models view the allocation problem as a complex one and permit direct consideration of multiple funding options and the effects of uncertain parameters.

A summary comparison of optimization methods is included in Table 4. Depending upon the combination of methods used in the evaluation system, the benefit-cost approach is generally the fastest and easiest to use. One of the simplest combinations consists of using successive ratings to order the projects and then dividing by expected costs. When alternatives need to be considered beyond what is feasible with a benefit-cost approach, a host of other models is available. The two described require more data equipment and analytical time than the benefit-cost approach, but they also provide more information.

Although some aspects of the latter models are identified rather specifically, considerable flexibility is inherent in each of them. The benefit function of the simulation model consists of economic returns only. However, the function could be expanded to include noneconomic variables also. Each of the models is flexible as to the combination of ranking methods that can be used to measure benefit. For example, a scoring model has been used to weight research objectives as part of a benefit contribution

Table 4. Resource allocation optimization methods

Item	Optimization method		
	Benefit cost	Atkinson-Bobis simulation model	Baker, *et al.* network model
Variables in benefit function	Flexible, generally economic	Economic returns	Flexible
Form of benefit function	Point	Functional relationship between date of research success and benefit	Linear or nonlinear approximated by piecewise linear segments
Number of project funding options permitted	1	∞	∞
Number of constraints permitted	1 (budget)	1 (5-year budget)	Finite number (budget)
Method of handling uncertainty	Manual sensitivity	Simulation	Sensitivity analysis through interaction
Number of periods over which funding is optimized	1 period	Up to 5 periods	1 period
Speed of use	Fastest	Slow relative to benefit cost	Slow relative to benefit cost
Equipment required for solving allocation problem	None	Computer	Computer
Cost of using method (data sources, computer, analyst)	Least	High relative to benefit cost	High relative to benefit cost
Comments	Computer can be used to reduce manual time requirements		Tabulates requirements for nonbudgetary resources also

model that estimates benefits of projects to which an allocation of funds is subsequently proposed by the network model.

Framework for Investment in Management Tools

Conceptually, the decision framework for optimal investment in management is the same as for any other investment option: purchase units of management until the marginal value added per dollar spent is equal to the marginal value of the dollar invested in the next best alternative. Since administration costs typically come out of the research budget, this framework is also valid for research management investment decisions. Management approaches are in direct competition with research projects for resources. Therefore, the management approaches which add the most to the expected value of research (because of a better decision) per dollar spent should be engaged until the value gained from another dollar's investment is no greater than if invested in the marginal research project. This would equalize the marginal rate of return from alternative lines of investment. Hence, the amount of management used in different organizations could vary also. If all the research options in one organization are expected to yield a very high rate of return, its investment in management tools should be restricted to those that will yield at least as high a return through improved decisions. Another organization, with lower and more varied rates of return expected on research options, could afford to invest in more management.

The major problems in implementing such a framework are not conceptual. They are measurement problems: how to determine which management approach is dollar for dollar better than another and how to measure value from management tools in the same units as research projects. While much work has been undertaken to develop new ways for subjectively ranking projects and allocating resources to them, far less has been done to determine which is the best management approach to use. In fact, only one paper appears to have directly addressed this problem; Souder [20] recently reported the application of a scoring model to an evaluation of 26 project selection models. Opinions were solicited from administrators and management scientists concerning the status of the models with respect to five criteria—realism, flexibility, capability, ease of use, and cost. The criteria were subjectively weighted and an overall score derived for each model. The only model included in that evaluation and also discussed in this paper, the Atkinson-Bobis model [2], tied for the highest score.

Laboratory costs to obtain reasonably *objective* measures of costs and benefits of research management tools would likely be prohibitive. Controlled experiments would be necessary over lengthy periods of time sufficient to observe the benefits resulting from research projects selected with different tools. One is probably limited for practical purposes to *subjective* measures. Souder's subjective scoring approach provides a useful comparison of a number of management methods. However, it is not sufficient for determining the optimum level of investment in management. Factors of both benefit (e.g., realism and capability) and cost (e.g., dollar costs and ease of use) were included in the score. To determine the optimal investment in such management methods, benefits and costs must be separated and measured in the same units as research projects. The dollar metric approach previously discussed has potential as an initial mechanism for subjectively placing management tools and research projects in comparable units of measurement. Then the marginal principle could be applied to both sets of options to select the optimum portfolio.

Summary

Considerable research has been conducted to develop management tools for possible substitution for or complementary use in current subjective decision processes. This literature has been selectively surveyed to emphasize the breadth of methodological developments for research project selection and resource allocation. A partial comparative evaluation of the selected methods is included with the survey. Applicability of the marginal principle for determining the optimum investment in research management has been emphasized and a rudimentary framework for implementing that principle suggested. Many research challenges remain in the area of methodological development. Particularly great is the need for innovative thought and practical experimentation to compare costs and benefits of alternative subjective decision processes.

References

[1] *A National Program of Research for Agriculture,* Report by Assoc. of State Univ. and Land Grant Colleges and USDA, Oct. 1966.

[2] ATKINSON, A. C., AND A. H. BOBIS, "A Mathematical Basis for the Selection of Research Projects," *IEEE Trans. on Engin. Mgt.* EM-16:2–8, Feb. 1969.

[3] BAKER, N. R., AND J. R. FREELAND, "Recent Advances in R & D Value Measurement and Project Selection Methods," paper presented at the 41st National Meeting of ORSA in New Orleans, April 1972.

[4] BAKER, N. R., AND W. H. POUND, "R & D Project Selection: Where We Stand," *IEEE Trans. on Engin. Mgt.* EM-11:124–134, Dec. 1964.

[5] BAKER, N. R., C. R. SHUMWAY, P. M. MAHER, AND W. E. SOUDER, "An R & D Project Selection and Budget Allocation Model for Large, Decentralized Research Organizations," paper presented at the meeting of TIMS, Detroit, Oct. 1971.

[6] CARTWRIGHT, R. W., "Research Management in a Department of Agricultural Economics," unpublished Ph.D. thesis, Purdue University, 1971.

[7] CETRON, M. J., JOSEPH MARTINO, AND L. A. ROEPCKE, "The Selection of R & D Program Content—Survey of Quantitative Methods," *IEEE Trans. on Engin. Mgt.* EM-14:1–13, March 1967.

[8] CHURCHMAN, C. W., R. L. ACKOFF, AND E. L. ARNOFF, *Introduction to Operations Research,* New York, John Wiley and Sons, Inc., 1957.

[9] DALKEY, N., AND O. HELMER, "An Experimental Application of the Delphi Method to the Use of Experts," *Mgt. Sci.* 9:458–467, April 1963.

[10] DEAN, B. V., AND L. E. HAUSER, "Advanced Material Systems Planning," *IEEE Trans. on Engin. Mgt.* EM-14:21–43, March 1967.

[11] FISHEL, W. L., ed., *Resource Allocation in Agricultural Research,* Minneapolis, University of Minnesota Press, 1971.

[12] GUILFORD, J. P., *Psychometric Methods,* New York, McGraw-Hill Book Company, Inc., 1954.

[13] LUCE, R. D., AND HOWARD RAIFFA, *Games and Decisions,* New York, John Wiley and Sons, Inc., 1957.

[14] MOORE, J. R., AND N. R. BAKER, "A Computational Analysis of an R & D Project Scoring Model," *Mgt. Sci.* 16:B212–232, Dec. 1969.

[15] ———, "An Analytical Approach to Scoring Model Design: Application to Research and Development Project Selection," *IEEE Trans. on Engin. Mgt.* EM-16:90–98, Aug. 1969.

[16] MOTTLEY, C. M., AND R. D. NEWTON, "The Selection of Projects for Industrial Research," *Oper. Res.* 7: 740–751, Nov.–Dec. 1959.

[17] NUTT, A. B., "An Approach to Research and Development Effectiveness," *IEEE Trans. on Engin. Mgt.* EM-12:103–112, Sept. 1965.

[18] PAULSON, ARNOLD, AND D. R. KALDOR, "Evaluation and Planning of Research in the Experiment Station," *Am. J. Agr. Econ.* 50:1149–1162, Dec. 1968.

[19] PESSEMIER, E. A., AND N. R. BAKER, "Project and Program Decisions in Research Management," *R & D Mgt.* 2:3–14, Oct. 1971.

[20] SOUDER, W. E., "A Scoring Methodology for Assessing the Suitability of Management Science Models," *Mgt. Sci.* 18:B526–543, June 1972.

[21] U. S. Bureau of the Census, *Statistical Abstract of the United States,* Washington, 1960–1972.

Solid Waste Management for Rural Areas: Analysis of Costs and Service Requirements*

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Federal and state legislation is increasingly making solid waste management an important service provided by rural communities and planning regions. Few systems have been designed for rural areas, and few studies have included data on spatial effects of collection density and transfer distances to disposal sites. Models are given estimating quantity of solid waste generated and costs per ton of solid waste collected, transferred, and disposed for different service areas and alternative technologies. The data can be used to project quantities of solid waste for collection and disposal and to determine optimum site location of disposal facilities in rural regions.

SOLID waste management is fast becoming a major service function of local government jurisdictions. Annual public outlay for refuse collection and disposal is exceeded at the local level only by expenditures for schools and roads. The total public and private refuse collection and disposal bill currently exceeds $3 billion annually [13, p. 6].

Interest in solid waste management at the local level has been stimulated by federal and state legislation concerned with the environmental threat of ever increasing quantities of waste products. The state of Oklahoma recently passed legislation prohibiting open burning except for some agricultural purposes. By 1974 a State Department of Health permit will be required by all cities to operate a sanitary landfill [The Oklahoma Solid Waste Management Act of 1970, HB No. 1499]. Federal legislation is contained in the 1965 Solid Waste Disposal Act [Title II of Public Law 89-272] and amended by the Resource Recovery Act of 1970. Of primary importance to rural areas are those actions providing grant support for the development of area-wide solid waste management systems—both to end fragmentation of responsibilities among small communities and to provide technical assistance to local governments with solid waste problems [13, p. 8].

To plan efficient solid waste systems, it has become apparent that more detailed information is needed on service requirements and factors affecting costs of solid waste collection and disposal for rural environments. Metropolitan plans for collection and disposal of solid wastes are of little help since their problems are significantly different than those faced in rural areas. Availability of landfill sites, location and size of transfer stations, and meeting air quality standards for incinerators are major problems of the metropolitan centers. Rural areas in general have a minimum of these problems but are faced with small or poorly organized systems and high costs for collection and disposal services.

Objectives and Procedures

The objectives of this paper are to outline briefly a general framework for public solid waste management services; to model and estimate empirically the generation of solid wastes for a substate planning region; and to model and estimate empirically the costs of supplying solid waste collection, transfer, and disposal services for rural regions. An interindustry model is utilized to show empirically how solid waste generation can be estimated for a region. Budget methods and cross-section data are used to estimate empirically the costs of supplying solid waste collection and disposal services.

Public Solid Waste Management Systems

The problems of planning public services are many and well documented in the literature [4, 11, 16]. Of particular importance is an interpretation of public demand for community services. One decision framework is to use an iterative approach to determine level and quality of service a community or substate region desires. Output of the public service sector is evaluated by community decision makers, and corrections in the system are made through policies under their control.

Examination of a solid waste management system within the framework for substate

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planning requires models describing waste generation, spatial location of wastes, and a collection, transfer, and disposal process.

Ideally, a waste generator model furnishes a substate region with information about the quantity and type of solid waste produced by the region's producing and consuming sectors. The level and kinds of economic activity within a region influence the solid waste generation since different industries produce different quantities of solid wastes. Changes in the level and kinds of economic activity and population have the greatest immediate impact upon generation of solid wastes. The spatial location of solid wastes is expressed as a function of service area output, employment, and resident location.

A collection, transfer, and disposal model serves as an aid in planning and implementing changes in a solid waste management system. The primary concern in selecting a solid waste system is cost. A cost model may be expected to assist in the selection of the most efficient mix of equipment and employees; the optimum locations of waste pickups, routes, transfer stations, and disposal sites; most desirable frequency of collection; and type of ultimate disposal. The model also assists in establishing rate schedules appropriate to different users of the service.

Solid Waste Generation

Application of an input-output model

Solid waste generation within a substate planning region can be estimated by treating solid waste production as if it were a primary resource requirement in an input-output model [12, p. 14].[1] If a relation exists between solid waste generation and regional output, total solid waste type k, W_k, is a function of output (dollars of total gross output) of all sectors, X_j. A coefficient for wastes of type k in sector j is the ratio of solid waste generated by sector j (physical units such as tons or cubic yards) to the output of sector j:

$$(1) \quad w_{kj}=\frac{W_{kj}}{X_j}\,;\ j=1,\cdots,n;\ k=1,\cdots,m;$$

and $W_{kj}=w_{kj}X_j$ expresses the total solid waste generation of type k associated with the output of sector j.

All solid wastes generated of type k for n sectors can be expressed algebraically as:

$$(2) \qquad W_k = \sum_{j=1}^{n} W_{kj} = \sum_{j=1}^{n} w_{kj}X_j$$

and in matrix form:

$$(3) \qquad W_k = w_k X$$

where w_k is a row vector of solid waste coefficients. The total generation of solid wastes of type k associated with final demand Y is:

$$(4) \qquad W_k = w_k X = w_k(I - A)^{-1}Y.$$

Multiplication of the vector of solid waste coefficients w_k times the interdependence coefficients $(I-A)^{-1}$ gives the direct and indirect amount of solid waste generated per dollar of output delivered to final demand. Induced amounts of solid waste generated for disposal assumes households and state and local government endogenous. Residential waste is incorporated in the model through use of an average residential waste per dollar of household income coefficient.

Waste generator

Solid waste coefficients and an interindustry model comprise a waste generator.[2] Table 1 presents solid waste coefficients, employment, total wastes generated, and a set of direct, indirect, and induced waste coefficients in thousands of pounds of waste per year per employee. Types of solid waste from agriculture and mining enterprises were excluded from this analysis. The waste coefficient for petroleum refining represents only employment in asphalts and paint production. Most trade and business sectors are represented by an average estimate for commercial and institutional wastes. The highest waste coefficient, 82.504, is associated with construction and the lowest, 1.348, is associated with apparel manufacturing.

Multiplication of solid waste coefficients times 1970 estimated employment furnishes an estimate of wastes in thousands of pounds per year associated with regional endogenous sec-

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[1] An alternative approach is to consider waste generation activities as separate endogenous sectors in the input-output model [7, p. 50].

[2] The present interindustry model defines regional output and interindustry flows in terms of persons employed. This is in keeping with most economic base studies for small areas [see 18]. Solid waste coefficients in [2] and [7] are reported in thousands of pounds of solid waste per year per employee. Under this formulation, output multipliers are also employment multipliers and $w_k(I-A)^{-1}$ shows the total (direct, indirect, and induced) solid waste generated per person employed for delivery of output to final demand.

Table 1. **Direct, indirect, and induced solid waste coefficients and solid waste generation, planning region nine, South Central Oklahoma, 1970**

Sector	Solid Waste[a] Coefficient, (1,000 lbs. per employee)	Employment 1970	Waste in Thousands of Pounds Per Year	Direct, Indirect, and Induced Solid Waste Coefficients (1,000 lbs.)
Farms-Ranches (1)	—	11,370	—	20.246
Agricultural Service (2)	7.620	1,128	9,357	34.246
Mining (3)	—	2,280	—	24.358
Construction (4)	82.504	2,589	213,603	106.197
Transportation (5)	7.620	1,772	13,503	22.293
Finance-Real Estate (6)	7.620	3,194	24,338	23.702
Utilities (7)	7.620	1,557	11,864	24.209
Food Manufacturing (8)	9.479	931	8,825	52.884
Apparel Manufacturing (9)	1.348	1,591	2,145	15.906
Wood-Paper (10)	26.459	227	6,006	40.086
Printing-Publishing (11)	16.500	517	8,531	30.604
Petroleum Refining (12)	19.394[b]	664	12,878	65.463
Leather-Plastic-Rubber (13)	15.006	82	1,230	32.096
Concrete Products (14)	5.280	471	2,487	19.195
Metal Manufacturing (15)	2.937	3,936	11,560	16.991
Construction Materials (16)	7.620	558	4,252	28.957
General Sales (17)	7.620	1,747	13,312	23.760
Food Sales (18)	35.700	1,592	56,834	66.454
Gasoline Service (19)	7.620	800	6,096	40.261
Auto Sales (20)	7.620	1,333	10,175	26.845
Clothing Sales (21)	7.620	767	5,845	22.861
Furniture Sales (22)	7.620	567	4,321	33.586
Eating Establishments (23)	7.620	2,620	19,964	24.098
Miscellaneous Retail (24)	7.620	1,218	9,281	23.411
Lodging (25)	7.620	527	4,016	28.806
Personal Services (26)	7.620	1,786	13,609	21.522
Business Services (27)	7.620	1,248	9,510	22.125
Professional Services (28)	7.620	2,064	15,728	21.113
Automobile Repair (29)	7.620	461	3,513	26.395
Recreation (30)	7.620	338	2,576	24.476
Miscellaneous Repair (31)	7.620	286	2,179	26.299
Medical Services (32)	7.620	2,342	17,846	23.823
Wholesale Trade (33)	7.620	2,032	15,484	20.037
Households	2.089[c]	69,188	144,534	12.417
State and Local Gov't	7.620	8,097	61,699	23.034
Federal Employees[d]	7.620	2,752	20,970	
Off Base Military	2.089	9,100	19,010	
Total			787,063	

[a] Sectors 8–15 and 18 calculated from [2]. Remaining sectors derived from [7].
[b] Refining wastes excluded.
[c] Average residential waste per employee of the labor force.
[d] Excludes federal civilian employment at Fort Sill.

tors including state and local government and household consumption. This estimate when added to the regional wastes generated by federal employment and off-base military households furnishes an estimated regional waste generation of 787 million pounds during 1970, or 9.7 pounds per day per person.

Projecting waste generation

A set of direct, indirect, and induced solid waste coefficients furnishes projection parameters of amounts of solid waste generated by each sector's additional delivery to final demand requiring one additional employment unit. These coefficients, recorded in the last column of Table 1, have a range of 12 to 106.

Direct effect of an additional employee by sector in terms of generated solid waste is equal to the coefficient in column two. Indirect effect is the sum of the repercussions in generation of solid waste in other economic sectors due to an employment increase in a sector for delivery to final demand. Induced effect accounts for additional employment required to service household consumption and purchases by state and local government. The strength of the interindustry model for projection is its ability to capture the indirect and induced effects of solid waste generation throughout the entire regional economy. The direct amount of solid waste produced by a specified change in regional employment can be estimated at a single source, but the indirect and induced effect, revealed to be two or three times larger than the direct effect, is distributed throughout the region.

Limitations of the waste generator

The direct, indirect, and induced solid waste coefficients are subject to limitations of the theoretical input-output model, empirical data used in estimating the regional input-output model, and survey data adapted for estimating solid waste coefficients.[3] A further limitation is failure to describe solid waste generated for disposal. In one study it was estimated that only 34 percent of the wastes generated actually enter public disposal sites [7, p. 40]. Solid wastes for disposal might be estimated in the waste generator by method and type of collection process for purposes of consistency with the collection, transfer, and disposal model. That is, residential waste, which has one method and cost of collection, can be distinguished in the waste generator as waste of type $k=1$. Commercial and institutional waste, which is publicly collected and disposed ($k=2$), can be distinguished from that portion which is privately collected and transferred but disposed of in a public site ($k=3$). The remaining solid wastes may be eliminated from the planning model unless they are in some way a nuisance to the public, and policy-makers wish to exert some control over their disposal.

Costs of Supplying Solid Waste Collection and Disposal Services

The literature concerning refuse collection does not show any significant economies of size [10]. Quality of service and density of residential and commercial areas far outweigh any effects of scale economies or diseconomies for the relevant range in rural areas. Quality of service is reflected in collection frequency, pickup location, and nature of pickup [9]. The latter two service qualities are extremely important for rural areas because they affect the type of technology that can be used and, subsequently, collection costs. For urban areas service qualities usually refer to container location for individual residences (i.e. curb versus side or back of house) and/or the requirement that garbage be separated from trash. In rural areas, service qualities compare such things as single versus multiple resident container use and curb or alley permanent location of multiple resident container.

Because of lumpiness of equipment items and health laws requiring daily covering of solid waste in sanitary landfills, economies of size in operating disposal sites are significant. Economies of size over both collection and disposal services are limited in rural areas by increased transfer costs as the number of collection areas are increased for a given disposal site.

Costs of refuse collection

Budget data have been used to calculate cost per collection and per ton of solid wastes for two systems using different technologies. The data have been supplemented with time and motion observations on individual routes for both systems to determine the effects of pickup density and nonroute miles on collection costs; both factors are important for rural areas.

The two technologies included a municipality system using rear loading technology and an institutional system using front loading technology. The two systems are not usually thought of as perfect substitutes although both can handle commercial containers by hydraulic systems. Front loading compaction is by far the most common system used in residential areas comprising 87 percent of the units sampled in a national survey [15]. Front loading, containerized compaction systems are designed for one man operation although, as in the system observed here, two men are frequently used for safety and cleanup purposes.[4]

Cost per collection crew.—Annual cost per collection crew including vehicle and container costs but excluding fixed overhead cost was about $21 thousand for the three man rear loading system versus $23 thousand for the two man front loading system. Both systems averaged a little less than five hours per day of route and transfer time exclusive of coffee and lunch breaks but including time at the landfill. In the municipal system crews worked until their route was finished for five days a week. Hence their wage bill was totally distributed over route and transfer time. Crews in the institutional system were required to work forty hours per week and average six routes of approximately five hours each route. The rest of their work week included minor repair and shuffling of containers and a few special collection jobs, but in general did not include anything significant that was not part of the collection route system. Their wage bill was also distributed over route and transfer time.

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[3] See George E. Muncrief [14] for the complete substate input-output model on which these data are based.

[4] Our purpose here is not to compare all technologies since differences frequently reflect needs or quality of service desired. For a description and relevant data by system see [15].

Cost per collection.—Collection rates, expressed as the number of collections made per collection and transfer hour, were estimated as a function of density of collections per route mile, number of nonroute miles and, for the municipal system, percent commercial collections. The hypothesis of the relationship is that the collection rate will increase the more dense are the household and commercial collections for any given service area, since less time is required by the crew and compaction vehicle to move between collection points. Further, it is expected that the collection rate will decrease the more nonroute miles there are associated with any service area. Nonroute miles are a proxy for size of community and subsequent distance to the solid waste disposal site. At this stage of the analysis, the disposal site is assumed to be located at the edge of the city. Collection rate is also expected to decrease the greater the percentage of commercial collections for any given service area of the municipal system. Since commercial collections require more time for hookups of the containers to the hydraulic system and more frequent trips to the disposal site because of larger waste volumes per collection, the collection rate is expected to decrease for increasing percentages of commercial collections.

Regression analysis was used to estimate the functional relationship between collection rate and the three explanatory factors. Observations on the municipal sytem included data on each of the 23 biweekly routes plus a daily 100 percent commercial route. For the institutional system, two collection crews cover several route combinations over a two week cycle, and hence daily observations for the cycle were recorded. The results of the regression equations are the following:

Municipal system

$$\text{(5)}\quad \begin{array}{ll} COLR = 66.5028 - 1.2247\,NRM & + 0.788\,DEN - 0.1684\,PCOM \\ \text{standard errors} \qquad (0.6779)^{*} & \quad (0.166)^{***} \qquad (0.2031) \end{array}$$

$$R^2 = .71 \qquad n = 24$$

Institutional system

$$\text{(6)}\quad \begin{array}{ll} COLR = 4.0954 - 0.0391\,NRM & + 1.9156\,DEN \\ \text{standard errors} \qquad (0.0400) & \quad (0.2356)^{***} \end{array}$$

$$R^2 = .85 \qquad n = 15$$

where

$COLR$ = COLlection Rate, number per hour,
NRM = Non-Route Miles,
DEN = DENsity, number of collections per route mile,
$PCOM$ = Percent COMmercial (by number of collections),
$*$ = Student's t test significant at the 10 percent level,
$***$ = Student's t test significant at the 1 percent level.

Results of the regression analysis show density of collections to be highly significant in explaining collection rate for both systems. Nonroute miles appeared to be significant in the municipal system but not in the institutional system.

Total cost per collection can now be estimated by residential and commercial service areas:

$$\text{(7)}\quad \begin{aligned} TCPCOL &= FCPCOL + CRCCOL \\ &\quad + COCCOL \\ FCPCOL &= TAFC \div NACOL \\ CRCCOL &= CRCPHR \div COLR \\ CRCPHR &= [COLCRC - COCPCR] \\ &\quad \div NACRHR \\ COCCOL &= [NCOPCR \cdot NCOLCO \\ &\quad \div COCPCR \end{aligned}$$

where

$TCPCOL$ = Total Cost Per COLlection, (\$),
$FCPCOL$ = Fixed Cost Per COLlection, (\$),
$CRCCOL$ = CRew Cost per COLlection, (\$),
$COCCOL$ = COntainer Cost per COLlection, (\$),
$TAFC$ = Total Annual Fixed Cost, (\$),
$NACOL$ = Number Annual COLlections,
$CRCPHR$ = CRew Cost Per Hour, (\$),

Table 2. Solid waste collection rate, cost per collection, volume per collection, cost per ton collected, and other data: municipal system, rear loading, 1971

	Variable Name^{a}	Residential Service Areas	Commercial Service Areas with Containers
Number of Collections (annual)	*NACOL*	777,089	71,447
Fixed Cost per Collection ($)	*FCPCOL*	0.0415	0.0415
Crew Cost per Collection			
Crew Cost per Hour ($)	*CRCPHR*	15.93	15.93
Collection Rate (# per hr.)	*COLR*	78^{b}	37^{c}
Cost per Collection ($)	*CRCCOL*	0.2042	0.4305
Container Cost per Collection ($)	*COCCOL*	—	0.1516^{d}
Total Cost per Collection ($)	*TCPCOL*	0.2457	0.6236
Monthly Cost ($)		2.13^{e}	6.75^{d}
Volume per Collection (yd^{3})	*VPCOL*	0.0546^{f}	0.3537^{g}
Quantity per Collection (lbs.)^{h}	*APCOL*	19.66	127.33
Collection Cost per Ton ($)	*COLCTN*	24.99	9.80

[a] See text for model formulation.

[b] Average of 40 pickups per route mile, 16.5 non-route miles and zero percent commercial.

[c] Average of 10 pickups per route mile, 16.5 non-route miles and 100 percent commercial.

[d] Average of 2.5 pickups per container weekly.

[e] Two pickups weekly.

[f] Evaluated at zero percent commercial and 40 pickups per route mile.

[g] Evaluated at 100 percent commercial and 10 pickups per route mile.

[h] Assumed 360 lbs. per cubic yard of compacted (3:1) refuse following data in [7, p. 26].

$COLR$ = *COL*lection *R*ate, number per hour,
$COLCRC$ = annual *COL*lection *CR*ew *C*ost, ($),
$COCPCR$ = annual *CO*ntainer *C*ost *P*er *CR*ew, ($),
$NACRHR$ = *N*umber of *A*nnual *CR*ew *H*ou*R*s,
$NCOPCR$ = *N*umber of *CO*ntainers *P*er *CR*ew,
$NCOLCO$ = *N*umber annual *COL*lections per *CO*ntainer.

Tables 2 and 3 give the results of the cost per collection model for the municipal and institutional systems. Cost per collection varied from about 25 cents for residential collections to 62 cents for commercial collections where the municipality provides the container. For the institutional system, cost per collection varied from $1.36 where a one man crew is employed to $1.72 for a two man crew, assuming the same collection rate in both instances. Collection rates were evaluated at average conditions for density and nonroute miles in both systems.

Cost per ton of solid waste.—Volume per collection was estimated in the municipal system as a function of percent of commercial collections and density of collections. Individual route data were used as observations in a regression analysis. It was hypothesized that routes with a higher percentage of commercial collections would show a higher volume per collection. Density was a proxy variable for indicating low income neighborhoods or service areas. From a cursory inspection of collection routes in the observed municipal system, density would be positively correlated with low family incomes. Other studies show that amount of solid waste generated per family is somewhat correlated with income levels. Therefore, from the system discussed here, it would be expected that increased density would negatively influence volume of solid waste per collection.

Results of the regression for 30 observations in the municipal system are the following:

$$\begin{array}{lll} (8) & VPCOL = 0.0574 + 0.00297\,PCOM & \\ & \text{standard errors} \qquad (0.00026)^{***} & \\ & \qquad\qquad - 0.00007\,DEN & \\ & \qquad\qquad (0.00006) & \\ & \qquad R^2 = .84 \qquad n = 30 & \end{array}$$

where

$VPCOL$ = *V*olume *P*er *COL*lection, cubic yards at a 3:1 compaction ratio,
$PCOM$ = *P*ercent *COM*mercial (by number of collections),
DEN = *DEN*sity, number of collections per route mile.

Percentage commercial collections was highly significant in explaining volume per collection.

Table 3. Solid waste collection rate, cost per collection, volume per collection, cost per ton collected and other data: institutional system, front loading, 1971

	Variable Name^{a}	Two Man Crew	One Man Crew
Number of Collections (annual)	*NACOL*	31,772	31,772
Fixed Cost per Collection ($)	*FCPCOL*	0.2608	0.2608
Crew Cost per Collection			
Crew Cost per Hour ($)	*CRCPHR*	13.10	9.39^{b}
Collection Rate (# per hr.)	*COLR*	10.23^{c}	10.23^{d}
Cost per Collection ($)	*CRCCOL*	1.2805	0.9179
Container Cost per Collection ($)	*COCCOL*	0.1792	0.1792
Total Cost per Collection ($)	*TCPCOL*	1.7205	1.3579
Monthly Cost ($)^{e}		27.58	21.77
Volume per Collection (yd^{3})^{f}	*VPCOL*	0.7317	0.7317
Quantity per Collection (lbs.)^{g}	*QPCOL*	263.41	263.41
Collection Cost per Ton ($)	*COLCTN*	13.06	10.31

[a] See text for model formulation.

[b] Assumed 50 percent labor cost of two man crew.

[c] Evaluated at sample means of 13.4 non-route miles and 3.477 collections per route mile.

[d] Assumed equal productivity for one man crew as with two man crew.

[e] Average of 3.7 pickups per container per week.

[f] Computed as the average compacted volume per collection over a two week period.

[g] Assumed 360 lbs. per cubic yard of compacted (3:1) refuse following data in [7, p. 26].

Density was negatively correlated with volume per collection but was not significant.

Volume per collection for the institutional system was computed as the average compacted volume (3:1) per collection over a two week period.

Cost per ton of solid waste collected is expressed in the following model:

$$(9)\quad \begin{aligned} COLCTN &= TCPCOL \div QSWCOL \\ QSWCOL &= VPCOL \cdot WPCUBY \end{aligned}$$

where

$COLCTN$ = *COL*lection *C*ost per *T*o*N*, ($),
$QSWCOL$ = *Q*uantity of *S*olid *W*aste per *COL*lection, tons,
$WPCUBY$ = *W*eight *P*er *CUB*ic *Y*ard, tons.

Weight per cubic yard of solid waste is highly variable and depends upon many factors. Using data from Golueke [7, p. 26], the average weight of a number of samples of solid waste from typical residential areas was 360 pounds per cubic yard of compacted refuse at a 3:1 compaction ratio. Those results are assumed for this analysis.

Tables 2 and 3 give the results of the model on cost per ton of solid waste collected for the municipal and institutional systems. Cost per ton varied from about $25 for residential solid waste to $9.80 for commercial solid waste in the municipal system. For the institutional system, cost per ton varied from $13.06 for a two man crew to $10.31 for a one man crew. Volume per collection was evaluated at average density for residential and commercial service areas in the municipal system.

Spatial effects on collection costs.—Rural communities are frequently less densely settled than counterpart residential areas in larger cities. Subsequently, collection costs are expected to be higher. Combining several communities and service areas for purposes of utilizing common disposal sites and thus reducing unit costs of operation must be compared against increased costs of longer transfer distances in the collection and transfer process. These two spatial factors are described in the following models with empirical results given for the municipal and institutional collection systems.

Cost per collection as a function of density is described in the following relationship:

$$(10)\quad \begin{aligned} TCPCOL\,(DEN) = {} & FCPCOL \\ & + COCCOL \\ & + CRCPHR \\ & \div COLR\,(DEN). \end{aligned}$$

All variables have been previously defined in equations (5), (6), and (7). Density of collection is allowed to vary in equation (10) and has a subsequent affect on variable costs in the total cost per collection function.

Cost per collection as a function of transfer miles to a disposal site from the edge of a community or service area is given by the following model:

$$(11)\quad \begin{aligned} TCPCOL\,(TRM) &= TCPCOL\,(DEN) \\ &\quad + [CPTNM \cdot QSWCOL]\,TRM \\ CPTNM &= CTRM \div TKCAPQ \\ CTRM &= CPCRHR \div VEL \end{aligned}$$

where

$CPTNM$ = *C*ost *P*er *T*o*N* *M*ile, ($),
TRM = *TR*ansfer *M*iles,
$CTRM$ = *C*ost per *TR*ansfer *M*ile, ($),
$TKCAPQ$ = *T*ruc*K* *CAP*acity in solid waste *Q*uantity, tons,
VEL = *VEL*ocity, miles per hour.

Spatial effects on residential collection costs.—Parameter data for the residential portion of the municipal rear loading system is applied to equation (10) for purposes of showing density effects on collection costs. Utilizing average values for nonroute miles of the municipal system, the following results:

$$(12)\quad \begin{aligned} TCPCOL\,(DEN) = {} & 0.0415 + 15.93 \\ & \div [46.2952 + 0.788\,DEN] \end{aligned}$$

Cost per residential collection varies from about 30 cents for a density of 20 collections per route mile to about 21 cents for a density of 60. On a monthly basis with two collections per week the cost variation is $2.60 versus $1.82.

The effect on collection costs of increasing transfer distance is the following, assuming (1) a compaction truck capacity of 20 cubic yards and fully loaded, (2) 360 pounds per compacted cubic yard, (3) a transfer velocity of 40 miles per hour, and (4) results of the density function evaluated at 40 collections per route mile:

$$(13)\quad \begin{aligned} TCPCOL\,(TRM) = {} & 0.2457 \\ & + 0.001087\,TRM. \end{aligned}$$

Since equation (13) is linear, each additional transfer mile adds about one-tenth of a cent to each residential collection. A disposal site located 10 miles from the edge of the city adds 20 transfer miles and a cost of about 2 cents per collection. Monthly costs for the collection and transfer process with two collections per week is $2.38 for a disposal site 10 miles from the edge of the city and $2.60 when the disposal site is 25 miles out.

Spatial effects on commercial collection costs.—A similar spatial analysis is given for commercial collections utilizing the parameter data for the municipal rear loading system and the institutional front loading system. The results are the following, assuming (1) truck capacity of 20 cubic yards for the municipal system and 24 cubic yards for the institutional system, (2) 360 pounds per compacted cubic yard, (3) transfer velocity of 40 miles per hour, (4) average values for nonroute miles, and (5) two man crew for the institutional system:

Muncipal system

$$(14)\quad \begin{aligned} TCPCOL\ (DEN) &= 0.1931 + 15.93 \div [29.4552 + 0.788\ DEN] \\ TCPCOL\ (TRM) &= TCPCOL\ (DEN) + 0.001268\ TRM \end{aligned}$$

Institutional system

$$(15)\quad \begin{aligned} TCPCOL\ (DEN) &= 0.4400 + 13.10 \div [3.5715 + 1.9156\ DEN] \\ TCPCOL\ (TRM) &= TCPCOL\ (DEN) + 0.001797\ TRM. \end{aligned}$$

Service area collection and transfer costs.—Service area collection and transfer costs by ton of residential and commercial solid waste can now be estimated. Service areas can be defined as finely as an individual collection route where density, nonroute miles, percent commercial, and transfer distance are all measurable. However, to be consistent with the solid waste generator model of the previous section, a larger spatial division per service area will be more useful. Estimated costs of collecting and transferring the total solid waste for a delineated service area and by type of collection service is the following:

$$(16)\quad TCOLC = [TCPCOL\ (TRM) \div QSWCOL]\ TQSW$$

where

$TCOLC$ = Total COLlection Cost, ($),
$TQSW$ = Total Quantity of Solid Waste, tons.

Two potential sources of data for estimating total quantity of solid waste are the results of the solid waste generator model of the previous section or the number of residential and commercial collections made annually in the service area. The first source has the benefits of being directly part of an economic model and useful for projection purposes. The second source is more familiar to local planners and conducive to estimation through their land use models.

Costs of refuse disposal

For rural areas the apparent least cost method for disposing solid waste is by means of landfill. Golueke and McGauhey [7, p. 20] report an average cost for sanitary landfill of about $1.13 per ton of solid waste disposed with a range of $0.50 per ton to $2.00 per ton. For metropolitan areas with increasing problems of finding suitable disposal sites and hence increasing land and transfer costs, incineration is one alternative disposal method. Costs of incineration are reported to run from about $4.00 per ton to over $12.00 per ton. Clearly, for rural areas with an abundance of possible disposal sites, landfill is the least cost alternative. Recycling of solid waste is still in the experimental stage but when fully operational will probably show substantial economies of size.

Landfill disposal costs.—Survey data reported by Golueke and McGauhey [7, p. 23] were used to estimate cost per ton of solid waste disposed by means of landfill. Forty-one sites in California were surveyed with data reported on yearly waste disposed, annual wage payments, long term capital expenditures (site modification), short term capital expenditure (equipment depreciation), annual maintenance and equipment operation costs, and a series of qualitative characteristics. Land costs were not reported and are excluded here also. In addition, long term capital expenditures for purposes of site modification were excluded. Such costs vary substantially by location and by expected use of sites once landfill has been terminated [8]. It is frequently argued that increased value of reclaimed land reduces land and site modification costs to near zero, particularly if landfills are short-lived.

Cost per ton of solid waste disposed was regressed against the inverse relation of annual quantity of solid waste using 30 observations of complete data from the California study:

$$(17)\quad \begin{array}{ll} ACDPTN = 0.6479 + 28{,}380\ (1/TQSW) \\ \text{standard error} \qquad\qquad (4{,}973)^{***} \end{array}$$

$$R^2 = .54 \qquad n = 30$$

where

$ACDPTN$ = *A*verage *C*ost of *D*is*P*osal per *T*o*N*, (\$).

The inverse relationship of quantity of solid waste disposed annually is highly significant (1 percent level) although the total amount of variation in cost per ton accounted for is only 54 percent. Including important quality characteristics of the landfills could be hypothesized to account for more of the cost variation.

The cost per ton estimate of equation (17) was corrected for differences in costs between California and Oklahoma using a construction cost index for major U. S. cities [5] and was updated to the 1971 level from the 1968–69 observed data years using the Department of Commerce composite construction cost index [19]. These corrections amounted to a 2 percent reduction in cost per ton.

Capacities of over one million tons annually tend towards an adjusted cost of \$0.63 a ton, but such capacities are unrealistic for rural areas.[5] Cost per ton almost doubles for capacities of 50 thousand tons over the minimum cost size and equals \$3.42 per ton for capacities of only 10 thousand tons.[6]

Service area disposal costs.—Total cost of solid waste disposal can be estimated by service area or for a combination of service areas:

$$TCDP = ACDPTN \cdot TQSW \tag{18}$$

where

$TCDP$ = *T*otal *C*ost of *D*is*P*osal, (\$).

Total costs of service area collection, transfer, and disposal

Combining collection, transfer, and disposal costs for one service area or a combination of service areas and for several types of solid waste is the following:

$$\begin{aligned} TCSWS &= \sum_{k=1}^{m} TCOLC_k + TCDP \\ TCOLC_k &= COLCTN_k \cdot TQSW_k \\ TCDP &= ACDPTN \cdot \sum_{k=1}^{m} TQSW_k \end{aligned} \tag{19}$$

where

$TCSWS$ = *T*otal *C*ost of *S*olid *W*aste *S*ervices, (\$),
$TCOLC_k$ = *T*otal *COL*lection *C*ost of the kth type of solid waste, (\$),
$COLCTN_k$ = *COL*lection *C*ost per *T*o*N* of the kth type of solid waste, (\$),
$TQSW_k$ = *T*otal *Q*uantity of *S*olid *W*aste of type k in the service area, (tons),
$TCDP$ = *T*otal *C*ost of *D*is*P*osal, (\$),
$ACDPTN$ = *A*verage *C*ost of *D*is*P*osal per *T*o*N*, (\$).

Table 4 is the summarized data for the observed service area in Oklahoma. Transfer costs were assumed zero since for the observed area the landfill site was at the edge of the city.

It should be noted that total quantity of solid waste of type k can be estimated from the waste generator as described in the earlier section or, as in this case, from the estimated total number of annual collections in the service area.

Table 4. Total cost of collection and disposal of solid waste for an observed service area

Type of Solid Waste for Disposal	k	Collection Cost per Ton of Solid Waste (\$) $COLCTN$	Disposal Cost per Ton of Solid Waste (\$) $ACDPTN$	Collection and Disposal Cost per Ton (\$)	Quantity of Solid Waste, tons $TQSW$	Cost of Collection and Disposal (\$) $TCSWS$
Municipal						
Residential	1	24.99	1.91	26.90	7,639	205,489
Commercial	2	9.80	1.91	11.71	4,549	53,269
Institution	3	13.06	1.91	14.97	4,185	62,649
Private (25 percent of Total)	4	—	1.91	1.91	5,457	10,423
Total	—	—	—	—	21,830	331,830

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[5] Observations on quantities in the California study ranged from 12 thousand tons annually to over one million tons.

[6] Landfill costs have also been budgeted in Oklahoma for annual capacities of about 20 thousand tons [3]. For such small capacities, budgeted costs per ton of solid waste have been up to 50 percent less than the reported regression results. An Indiana study, however, shows a budgeted cost of about \$2.35 per ton in 1970 exclusive of land cost for an annual capacity of 20 thousand tons [1].

Conclusions

The process of planning a solid waste system for a community or substate region is not completed at this stage. Some might say that the real process of planning is just commencing. Assuming it was known how much and what quality of service was desired, the opportunity is seldom available to plan a completely new system for a substrate region. The planners and community decision makers must interchange ideas and facts at this stage in order that decisions (incremental or otherwise) will be focused in the right direction to yield levels and qualities of public services consistent with social goals.

The results of this study indicate that small rural communities will probably have to pay more for collection and disposal services than small metropolitan areas in the 50,000 to 250,000 range for two reasons. First, rural communities are generally less densely settled than the metro areas. Decreasing density by 50 percent in a budgeted municipal system has the effect of increasing collection costs by 20 percent. If a different technology is used which permits multiple resident use of strategically placed containers, it is possible that collection costs will not increase. However, it can be argued that the same quality of service is not being provided. Second, because of imperfect divisibility of capital inputs, landfill disposal methods show significant economies of size.

Excluding land costs, expected disposal cost per ton of solid waste was more than three times as much for the smallest landfill capacity versus the capacity for a metropolitan area of about 250,000 population. Increased transfer costs in the metropolitan area will tend to eliminate part of this advantage. At the same time, rural areas may be able to reduce total collection and disposal costs by utilizing area-wide disposal facilities.

Solid waste management for rural areas may be one of those unique cases where decision making can be more than incremental due to fewer fixed facilities and certain legal mandates. Programming optimum locations of disposal sites and transfer systems would appear to provide high pay-offs in determining the least cost system for such areas [13, 7, 6, 17].

References

[1] Clayton, K. C., and J. M. Huie, *Sanitary Landfill Cost*, Lafayette, Purdue Univ. Extens. Serv. EC412, n.d.

[2] Combustion Engineering, Inc., *Technological-Economic Study of Solid Waste Disposal Needs and Practices*, Rockville, Maryland, U. S. Public Health Service Bureau of Solid Waste Management, Pub. 1886, 1969.

[3] Davis, R. G., "Solid Waste Management and Comprehensive Planning: Analysis of Costs and Service Requirements for Rural Areas," unpublished M.S. thesis, Oklahoma State University, 1973.

[4] Day, L. M., "Community Facilities and Services: An Economic Framework for Analysis," *Am. J. Agr. Econ.* 50:1195–1205, Dec. 1968.

[5] Godfrey, R. S., *Building Construction Cost Data 1970*, Duxbury, Mass., Robert Snow Means Company, Inc., 1970.

[6] Golueke, C. G., *Comprehensive Studies of Solid Waste Management: Third Annual Report*, Washington, U. S. Environmental Protection Agency, 1971.

[7] ———, and P. H. McGauhey, *Comprehensive Studies of Solid Waste Management: First and Second Annual Reports*, Washington, U. S. Public Health Service Pub. 2039, 1970.

[8] Havlicek, J., Jr., G. S. Tolley, and Y. Wang, "Solid Wastes—A Resource?" *Am. J. Agr. Econ.* 51:1598–1602, Dec. 1969.

[9] Hirsch, W. Z., "Cost Functions of an Urban Government Service: Refuse Collection," *Rev. Econ. and Stat.* 47:87–92, Feb. 1965.

[10] ———, "The Supply of Urban Public Services," in *Issues in Urban Economics*, eds. H. S. Perloff and L. Wingo, Jr., Baltimore, The Johns Hopkins Press, 1968.

[11] Margolis, J., "The Demand for Urban Public Services," in *Issues in Urban Economics*, eds. H. S. Perloff and L. Wingo, Jr., Baltimore, The Johns Hopkins Press, 1968.

[12] Martin, W. E., and H. O. Carter, *A California Inter-Industry Analysis Emphasizing Agriculture, Part I: The Input-Output Models and Results*, Davis, California, Giannini Foundation Research Report No. 250, Feb. 1962.

[13] Morse, M., and E. W. Roth, *Systems Analysis of Regional Solid Waste Handling*, Washington, U. S. Public Health Service Pub. 2065, 1970.

[14] Muncrief, G. E., "Development of Interindustry Analysis for Use Within a Public Service Planning Framework to Estimate Generation of Solid Wastes in South Central Oklahoma," unpublished M.S. thesis Oklahoma State University, May 1972.

[15] Ralph Stone and Company, Inc., *A Study of Solid Waste Collection Systems Comparing One-Man With Multi-Man Crews*, Washington, U. S. Public Health Service Pub. 1892, 1969.

[16] Schreiner, D. F., "Community Services in a Dynamic Rural Economy," in *Size, Structure, and Future of Farms*, eds. A. G. Ball and E. O. Heady, Ames, Iowa State University Press, 1972.

[17] Schultz, G. P., "Facility Planning for a Public Service System: Domestic Solid Waste Collection," *J. Regional Sci.* 9:921–307, 1969.

[18] Tiebout, C. M., *The Community Economic Base Study*, New York, Committee for Economic Development Supplementary Paper 16, 1962.

[19] U. S. Department of Commerce, Bureau of Domestic Commerce, *Construction Review*, 18 No. 4, April 1972.

Returns to Scale and Input Elasticities for Sugarcane: The Case of Sao Paulo, Brazil*

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Returns to scale and input elasticities are estimated from cost functions based on standard and generalized Cobb-Douglas production functions. Returns to scale increased up to 161 thousand tons and decreased thereafter. Elasticities were .340 for labor, .285 for land, .351 for fertilizer, .113 for pesticides, and —.089 for machinery and equipment.

THE Brazilian government recently announced a policy to increase the productivity and economic efficiency of Brazil's sugar industry.[1] The government has implemented this policy by offering the sugar industry fiscal and financial incentives for the merger, incorporation, and relocation of sugar plants.[2] If this policy achieves its intended objective, the Brazilian government would be able to set lower prices for sugar and alcohol and thereby expand domestic and foreign consumption. Success of this policy seems to rest on two conditions: the industry's acceptance of the fiscal and financial incentives, and increasing returns to scale in the production of sugarcane and/or the manufacturing of sugar and alcohol. Acceptance of the financial incentives would facilitate the merger and expansion process, and economies of scale would ensure lower costs for larger production units. The purpose of this paper is to estimate returns to scale and input elasticities for sugarcane produced in Sao Paulo, Brazil and to assess the implications of these estimates for the above policy.

Most previous estimates of costs and returns to scale in sugarcane production in Brazil pertain to small producers (*fornecedores*). Ettori *et al.* [5] found that during the 1966–67 season the average cost per ton of sugarcane in Piracicaba and Sertaozinho was Cr$17.48 on farms using mechanized cultivation and Cr$20.21 on farms using animal cultivation. Moraes [12] studied sugarcane costs incurred by *fornecedores* in Piracicaba during the 1963–64 season. He found there were no economies of scale because average cost did not decrease as quantity harvested increased. Based on a returns to scale estimate of .973, Zagatto *et al.* [16] concluded that *fornecedores* in Rio das Pedras operated under constant returns to scale. In a study of large farms located in several Brazilian states, Cline [2] concluded that returns to scale were constant because the estimated scale effect was 1.004. Zagatto *et al.* [16] and Cline [2] computed returns to scale by summing input elasticities estimated from a production function.

In this paper, returns to scale and production elasticities are estimated from a sample of sugarcane farms associated with the Central Cooperative of Sugar and Alcohol Producers in the State of Sao Paulo. Unlike previous studies, the estimates are derived taking into account the (implied) sugarcane quotas faced by sugarmill farms and the possibility of variable returns to scale.[3]

Model Formulation

Considering the predetermined quotas established for sugar, an appropriate model for the behavior of sugarcane producers is cost minimization subject to the production function and sugarcane quota. Given the general production function

$$(1) \qquad y = f(x_1, \cdots, x_n, v)$$

where y is quantity harvested, x is input, and v

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[1] On August 17, 1971, Brazil's Finance Minister announced that the major aim of the new policy was to reduce costs of sugarcane production and processing [6, p. 5].

[2] Merger occurs when two or more sugarmills are combined into a new sugarmill that receives the respective official quotas. Incorporation occurs when two or more sugarmills are absorbed by another sugarmill that receives the respective official production quotas. Relocation occurs when a single sugarmill is transferred to another location. These definitions were established by the Institute do Acucar e do Alcool (IAA) which is the official executor of government policies relating to the sugar sector.

[3] Although the Brazilian government places quotas only on sugar, the yield of sugar per ton of sugarcane is fairly constant at 94 kg./ton. Therefore, a production quota on sugar implies a production quota on sugarcane.

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is a random error term, the model becomes,

$$\min c - \lambda[f(x_1, \cdots, x_n, v) - y] \tag{2}$$

where

$$c = \sum_{i=1}^{n} p_i x_i, \tag{3}$$

and λ is a Lagrange multiplier. To solve (2), it is necessary to specify the form of the production function. The standard and generalized Cobb-Douglas production functions were selected,

(4) $y = a x_1^{b_1} \cdots x_n^{b_n} v$ standard Cobb-Douglas

(5) $y e^{\theta y} = a' x_1^{\alpha d_1} \cdots x_n^{\alpha d_n} v'$ generalized Cobb-Douglas.[4]

The returns to scale parameter ($r = \sum_{i=1}^{n} b_i$) for the standard form is invariant with respect to y. In contrast, the generalized form is based on the following returns to scale function,

$$\alpha(y) = \frac{\alpha}{1 + \theta y}, \tag{6}$$

where $\theta \gtrless 0$. For this function, $\alpha(y)$ equals α when either y or $\theta = 0$. The function decreases from α at $y = 0$ to zero as $y \rightarrow \infty$ when $\theta > 0$ and increases from α as $y \rightarrow (-1/\theta)$, then becomes negative for $y > (-1/\theta)$ when $\theta < 0$. Zellner and Revankar [17] used (5) to estimate returns to scale in the U. S. transportation equipment industry and obtained reliable estimates. Revankar [14] tried an alternative scale function and obtained large standard errors for certain parameters.[5]

Replacing the constraint in (2) by (4) and substituting the resulting input demand functions into the definition of cost ($c = \sum_{i=1}^{n} p_i x_i$) gives the following logarithmically transformed total cost function [13, pp. 105–108],[6]

$$\begin{aligned} C_j = K + \frac{1}{r} Y_j + \frac{b_1}{r} P_{1j} + \cdots \\ + \frac{b_n}{r} P_{nj} + Z_j, \quad (j = 1, \cdots, J), \end{aligned} \tag{7}$$

where capital letters denote natural logarithms of the variables and $Z_j = \ln v_j$ is assumed to be $NID(0, \sigma_z^2)$. Ordinary least-squares estimates of the coefficients of equation (7) provide estimates of the returns to scale parameter (r) and production elasticities (b_i),

$$\hat{r} = \widehat{(1/r)}^{-1} \quad \text{and} \quad \hat{b}_i = \widehat{(b_i/r)}\hat{r}. \tag{8}$$

Since $\sum_{i=1}^{n} (b_i/r) = 1$, this constraint is incorporated in (7) to obtain,

$$\begin{aligned} C_j - P_{nj} = K + \frac{1}{r} Y_j + \frac{b_1}{r} (P_1 - P_n)_j + \cdots \\ + \frac{b_{n-1}}{r} (P_{n-1} - P_n)_j + Z_j. \end{aligned} \tag{9}$$

b_n is estimated from the coefficients of equation (9),

$$\hat{b}_n = \hat{r} - \sum_{i=1}^{n-1} \hat{b}_i. \tag{10}$$

Following the same procedures with the generalized Cobb-Douglas function (5) gives the following cost function,

$$\begin{aligned} C_j - P_{nj} = K' + \frac{1}{\alpha} Y_j + \frac{\theta}{\alpha} y_j \\ + d_1(P_1 - P_n)_j + \cdots \\ + d_{n-1}(P_{n-1} - P_n)_j + Z_j' \end{aligned} \tag{11}$$

where Z_j' is assumed to be $NID(0, \sigma_{z'}^2)$. Ordinary least-squares estimates of the coefficients of Y_j and y_j are used to estimate the returns to scale function,

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[4] The variable returns to scale Cobb-Douglas production function can also be viewed as a special case of the generalized power production function [3], namely,

$$y = a \prod_{i=1}^{n} x_i^{f_i(x)}$$

where $f_i(x)$ is homogeneous of degree zero in x for all i.

[5] Specifically, Revankar [14, p. 70] considered the scale function

$$\alpha(y) = \alpha + m \frac{b - y}{b + y}; \; b > 0, \; \alpha > m \geq 0$$

where m and b are parameters. The estimate of b obtained using the generalized *VES* function exhibited large standard errors.

[6] The input demand functions are

$$x_i = k_i \frac{y^{-1/r} p_1^{b_1/r} \cdots p_n^{b_n/r} z}{p_i}$$

where

$$k_i = b_i [a b_1^{b_1} \cdots b_n^{b_n}]^{-1/r}$$

$$x_i^0 = v^{-1/r}, \quad \text{and} \quad r = \sum_{i=1}^{n} b_i.$$

$$\hat{\alpha}(y_j) = \frac{\hat{\alpha}}{1 + \hat{\theta} y_j}, \tag{12}$$

where

$$\hat{\alpha} = \widehat{\left(\frac{1}{\alpha}\right)}^{-1} \quad \text{and} \quad \hat{\theta} = \widehat{\left(\frac{\theta}{\alpha}\right)}\widehat{\left(\frac{1}{\alpha}\right)}^{-1}.$$

Input elasticities associated with the generalized Cobb-Douglas function are now derived. Letting b_i' denote the input elasticity,

$$b_i' = \frac{x_i}{y} \frac{\partial y}{\partial x_i}.$$

For the generalized production function $y = g(f)$ where in the present case

$$f = a' x_1^{\alpha d_1} \cdots x_n^{\alpha d_n} v'.$$

Therefore,

$$b_i' = \frac{x_i}{y}\left(\frac{dg}{df} \frac{\partial f}{\partial x_i}\right).$$

Noting that

$$\frac{\partial f}{\partial x_i} = \alpha d_i \frac{f}{x_i}$$

and applying Euler's theorem,[7]

$$\frac{dg}{df} = \alpha(y) y (\alpha f)^{-1}.$$

Hence,

$$\hat{b}_i' = \widehat{\alpha(y)} \hat{d}_i, \tag{13}$$

where $\hat{d}_i$'s are estimated from (11) and $\widehat{\alpha(y)}$ from (12). Notice that unlike the standard Cobb-Douglas function (which has constant input elasticities), the elasticities for the generalized Cobb-Douglas function vary with respect to y, provided $\theta \neq 0$. When $\theta = 0$, $b_i' = \alpha d_i = b_i$; hence (9) and (11) become identical with $r = \alpha$ and $d_i = b_i / r$.

Returns to scale and input elasticities for the Cobb-Douglas function have been estimated by other methods. Ulveling and Fletcher [15] incorporated variable returns to scale in the Cobb-Douglas function by expressing the input elasticities as a quadratic function of a capital intensity index. Returns to scale were computed indirectly by summing input elasticities (estimated from the production function) for different index values. For the method proposed here, the returns to scale function is indirectly estimated and the input elasticities (estimated from the cost function) are a function of the scale parameter. Lau and Yotopoulos [11] avoided the simultaneous equation bias in input elasticities estimated from the production function [8] by computing these elasticities from the coefficients of the UOP Cobb-Douglas profit function and certain related identities. Two assumptions of their work are that firms maximize profits and output is determined by the firm. Neither assumption is valid for sugarcane farms in Brazil.

Estimation

The production function for sugarcane was specified by the following standard and generalized Cobb-Douglas functions,

$$y = a \overset{5}{\underset{i=1}{\pi}} x_i^{b_i} v \tag{14}$$

$$y e^{\theta y} = a' \overset{5}{\underset{i=1}{\pi}} x_i^{\alpha d_i} v' \tag{15}$$

where

y = sugarcane harvested, tons;
x_1 = labor, man-days;
x_2 = land, hectares;
x_3 = fertilizers and lime, tons;
x_4 = chemical pesticides, kilograms;
x_5 = machinery and equipment, service-hours;
v, v' = random error terms.

The total cost functions corresponding to (14) and (15) are, respectively,

$$\begin{aligned} C - P_5 = K + \frac{1}{r} Y + \frac{b_1}{r}(P_1 - P_5) \\ + \cdots + \frac{b_4}{r}(P_4 - P_5) + Z, \end{aligned} \tag{16}$$

and

$$C - P_5 = K' + \frac{1}{\alpha} Y + \frac{\theta}{\alpha} y$$

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[7] From Euler's theorem and the fact that $\partial g / \partial x_i = \partial y / \partial x_i$,

$$x_1 \frac{\partial y}{\partial x_1} + \cdots + x_n \frac{\partial y}{\partial x_n} = \alpha(y) y.$$

Also, since $\partial y / \partial x_i = (dg/df)(\partial f / \partial x_i)$,

$$\frac{dg}{df}\left(x_1 \frac{\partial f}{\partial x_1} + \cdots + x_n \frac{\partial f}{\partial x_n}\right) = \alpha(y) y.$$

Substituting for $\partial f / \partial x_i$ and solving for dg/df gives (13).

$$(17) \qquad + d_1(P_1 - P_5) + \cdots + d_4(P_4 - P_5) + Z'$$

where

C = log of total cost of production on a crop year basis, cruzeiros;
y, Y = actual and log of quantity harvested, respectively, tons;
P_1 = log of price of labor, compound wage rate defined as the nominal wage rate plus administration and housing costs (when applicable), cruzeiros per man-day;
P_2 = log of price of land, sum of interest rate times the land's present value plus land tax, cruzeiros per hectare;
P_3 = log of price of fertilizers and lime including application costs, cruzeiros per ton;
P_4 = log of price of chemical pesticides including application costs, cruzeiros per kilogram;
P_5 = log of price of machinery and equipment, cruzeiros per service-hour.

Although P_5 is used to impose the constraint $\sum_{i=1}^{n} (b_i/r) = 1$ on the price coefficients, the estimated input elasticities would be the same regardless which of the five prices is used. Inputs that are substitutes or complements in production were aggregated in order to reduce multicollinearity and to avoid overestimation of input elasticities and returns to scale [7, 9]. Specifically, the price of fertilizer includes the cost of fertilizer and the cost of machinery and labor required to apply fertilizer. The same applies to the price of chemical pesticides. The price of labor includes only the cost of manual labor, and the price of machinery and equipment includes the cost of machinery not used in applying fertilizers and chemical pesticides.

Data were obtained from 24 sugarmill farms located mainly in the State of Sao Paulo, Brazil. Sample sugarmill farms harvested from 18,000 to 380,000 tons of sugarcane and ranged in size from 600 to 10,000 hectares during the 1970–71 crop year. All farms in the sample were members of the Central Cooperative of Sugar and Alcohol Producers in the State of Sao Paulo.[8] A more detailed discussion of the compilation of data and measurement of variables is given by Alcantara [1]. An analysis of average production costs for farms in the sample is reported in [4].

Results

The least-squares estimate of (16) is,[9]

$$(18) \quad C - P_5 = .319 + \underset{(.088)}{.914}Y + \underset{(.245)}{.505}(P_1 - P_5) + \underset{(.176)}{.096}(P_2 - P_5) + \underset{(.135)}{.304}(P_3 - P_5) + \underset{(.103)}{.152}(P_4 - P_5).$$

$$R^2 = .895$$

Figures in parentheses below each coefficient are standard errors. Price coefficients for land, labor, and chemical pesticides are not significantly different from zero at the 5 percent level.[10] The returns to scale parameter and production elasticities derived from the coefficients of equation (18) are given in Table 1. Except for machinery and equipment, the derived production elasticities are positive.[11]

Table 1. Returns to scale (r) and input elasticities (b_i) for sugarcane, standard Cobb-Douglas cost function, Sao Paulo, Brazil, 1970–71 season

Parameter	Estimated value
r (returns to scale)	1.094
b_1 (labor)	0.552
b_2 (land)	0.105
b_3 (fertilizers)	0.333
b_4 (chemical pesticides)	0.166
b_5 (machinery and equipment)	−0.156[a]

[a] Estimated by:

$$\hat{b}_5 = \hat{r} - \sum_{i=1}^{4} \hat{b}_i.$$

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[8] Of the 96 sugarmills currently located in Sao Paulo, 78 are associated with Central Cooperative. The associated mills account for nearly 85 percent of the sugar and alcohol produced in Sao Paulo.

[9] Even though the input prices enter the estimation equations as deviations from the price of machinery and equipment, the price coefficients in equation (18) represent estimates of b_i/r.

[10] Equation (18) was also estimated using the other input prices, i.e. P_1, P_2, P_3, and P_4, to impose the constraint that the sum of the price coefficients equals one. In all cases the coefficient b_5/r was not significantly different from zero at the 10 percent level. This finding does not imply that b_5 is not significantly different from zero.

[11] Since it was not possible to test the statistical significance of the input elasticities, the validity of the negative machinery-equipment elasticity is questionable. In economic terms a negative input elasticity implies that the input is being employed beyond the optimal level.

Testing whether the derived value of r is significantly different from one (constant returns to scale) is equivalent to testing whether the coefficient $1/r$ is significantly different from one. The t-test showed that this coefficient is not significantly different from one at the 5 percent level. Hence, for the standard Cobb-Douglas cost function, the hypothesis of constant returns to scale cannot be rejected.

The least-squares estimate of (17) is

$$(19)\quad C-P_5=2.683+\underset{(.244)}{.616Y}+\underset{(.0000018)}{.0000024y}$$

$$+\underset{(.272)}{.338}(P_1-P_5)+\underset{(.224)}{.284}(P_2-P_5)$$

$$+\underset{(.137)}{.349}(P_3-P_5)+\underset{(.106)}{.112}(P_4-P_5).$$

$$R^2 = .905$$

Figures in parentheses below each coefficient are the standard errors. The coefficients of y and the price of labor, land, and chemical pesticides are not significantly different from zero at the 5 percent level. The returns to scale parameter and production elasticities derived from the coefficients of (19) are given in Table 2.

The estimate $\hat{\alpha}(\bar{y})=1.005$ is based on the estimates $\hat{\alpha}=1.622$ and $\hat{\theta}=.00000386$; see (12). Although $\hat{\theta}$ is very close to zero, it has a substantial effect on $\hat{\alpha}(y)$ as indicated by the range of $\hat{\alpha}(y)$. The test for variable returns to scale is equivalent to testing whether $\hat{\theta}$ is significantly different from zero. Since $\hat{\theta}$ is a non-linear combination of the coefficients of y and Y, the small sample variance of $\hat{\theta}$ cannot be estimated. The large sample variance of $\hat{\theta}$ approximated by a Taylor expansion [10, p. 444] is .0000019.[12] The t-statistic for the hypothesis $\theta=0$ is 2.297 which exceeds the tabled t-value 2.11 (5 percent level with 17 degrees of freedom). Hence, the results for the generalized Cobb-Douglas cost function imply variable returns to scale. As previously noted, when $\theta\neq 0$, the elasticities for the generalized Cobb-Douglas function vary with respect to y. The estimated range for each elasticity corresponding to the extreme sample values of y are given in the last column of Table 2. Setting $\widehat{\alpha(y)}=(\hat{\alpha}/1+\hat{\theta}y)$ equal to one and solving for y indicates there are increasing returns to scale below and decreasing returns to scale above 161,000 tons. A comparison of the average elasticities in Tables 1 and 2 shows that the labor and chemical pesticides elasticities are greater and the land, fertilizer, and machinery and equipment elasticities are smaller for the standard than for the generalized Cobb-Douglas production function. For fertilizers and chemical pesticides, the elasticity range based on the generalized cost function includes the corresponding elasticity estimate obtained with the standard cost function.

Table 2. Returns to scale [$\alpha(y)$] and input elasticities (b_i') for sugarcane, generalized Cobb-Douglas cost function, Sao Paulo, Brazil, 1970–71 season

Parameter	Estimated value	
	Average[a]	Range[b]
$\alpha(y)$ (returns to scale)	1.005	.657, 1.517
b_1' (labor)	.340	.222, .513
b_2' (land)	.285	.187, .431
b_3' (fertilizers)	.351	.229, .529
b_4' (chemical pesticides)	.113	.074, .170
b_5' (machinery & equipment)	−.089[c]	−.054, −.126

[a] Evaluated at the mean, $\bar{y}=159{,}000$ tons.

[b] Lower limit corresponds to $y=380{,}000$ tons and upper limit to $y=18{,}000$ tons.

[c] Estimated by:

$$\hat{b}_5' = \widehat{\alpha(\bar{y})}\left(1-\sum_{i=1}^{4}\hat{d}_i\right).$$

Since cost function (18) implies constant returns to scale and (19) implies variable returns to scale, the two functions appear to give contradictory evidence about returns to scale in sugarcane production. A closer inspection of the results suggests that the returns to scale parameter estimated with the standard Cobb-Douglas cost function measures the average returns to scale for farms in the sample. Specifically, $\alpha(\bar{y})$ $(\bar{y}=159{,}000$ tons) and $\hat{r}$ are

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[12] In particular, $\hat{\theta}=\widehat{(\theta/\alpha)}/\widehat{(1/\alpha)}$, and letting $\hat{\beta}_1=\widehat{(\theta/\alpha)}$ and $\hat{\beta}_2=\widehat{(1/\alpha)}$,

$$\operatorname{var}(\hat{\theta}) \simeq \left(\frac{\partial\theta}{\partial\hat{\beta}_1}\right)^2 \operatorname{var}(\hat{\beta}_1) + \left(\frac{\partial\theta}{\partial\hat{\beta}_2}\right)^2$$

$$\operatorname{var}(\hat{\beta}_2) + 2\left(\frac{\partial\theta}{\partial\hat{\beta}_1}\right)\left(\frac{\partial\theta}{\partial\hat{\beta}_2}\right)\operatorname{cov}(\hat{\beta}_1,\hat{\beta}_2).$$

Therefore,

$$\operatorname{var}(\hat{\theta}) \simeq \widehat{\left(\frac{1}{\alpha}\right)}^{-2} \operatorname{var}\widehat{\left(\frac{\theta}{\alpha}\right)} + \left(-\frac{\widehat{\theta/\alpha}}{\widehat{1/\alpha}}\right)^2$$

$$\operatorname{var}(\widehat{1/\alpha}) + 2\widehat{\left(\frac{1}{\alpha}\right)}^{-1}\left(-\frac{\widehat{\theta/\alpha}}{\widehat{1/\alpha}}\right)\operatorname{cov}(\widehat{1/\alpha},\widehat{\theta/\alpha}).$$

quite similar, 1.005 and 1.094, respectively. Viewed in this manner, (18) and (19) are consistent and imply that average returns to scale approximately equal one, and returns to scale vary significantly over the range of output represented in the sample. Converting the total cost function (19) to an average cost (AC) function yields

$$\text{(20)} \quad \ln AC = 6.788 - .384Y + .00000238y$$

where the intercept includes the price effects (price coefficients of (19) times average input prices). Setting the first derivative of (20) with respect to Y equal to zero and solving for y gives the output at which average cost is a minimum ($13 per ton), namely 161,000 tons. This is the same output obtained by setting $\widehat{\alpha(y)}$ equal to zero and solving for y. Hence, average cost decreases with increases in output up to 161,000 tons and increases thereafter.

Since returns to scale appear to vary with output, the input elasticities reported in Table 2 are considered to be more valid than those in Table 1. It is not possible, however, to make meaningful recommendations about resource use based on these input elasticities. First, there is no consistent way to derive the marginal physical productivities (MPP) from the input elasticities.[13] Hence, the MPP-input price ratios which are typically used to assess resource use cannot be computed. Second, the economic assumption underlying the estimation procedure (cost minimization subject to the production function and quota) implies that sugarcane farms are using their inputs efficiently.

Summary and Conclusions

The purpose of this paper was to estimate returns to scale and input elasticities for sugarmill farms in Sao Paulo, Brazil. Since the sugarmills face predetermined production quotas for sugar, the economic model selected assumes that sugarcane producers attempt to minimize costs subject to the production function and implied sugarcane quota. Production of sugarcane was represented by a standard and generalized Cobb-Douglas production function. The latter allows for variable returns to scale whereas the former assumes that returns to scale are invariant with respect to output. Five inputs were included in the production functions: labor, land, fertilizer, chemical pesticides, and machinery and equipment. Returns to scale and elasticities were estimated from the cost functions by ordinary least squares using 1970–71 data from a sample of 24 sugarmill farms associated with the Central Cooperative of Sugar and Alcohol Producers in the State of Sao Paulo, Brazil.

The results showed increasing returns to scale up to 161,000 tons of sugarcane harvested and decreasing returns to scale thereafter with average returns to scale approximately equal to one. Based on this finding, it appears that the Brazilian government's policy to increase efficiency in the sugarcane industry should concentrate on the expansion and merger of sugarcane farms whose combined harvest of sugarcane is no greater than 161,000 tons per year. Given the existing technology, expansion beyond this level of output is not likely to reduce average costs due to the presence of diseconomies of scale.

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[13] For the standard Cobb-Douglas production function, input elasticities are constant and MPP varies with output. Input elasticities for the generalized Cobb-Douglas production function vary with output. Consequently, the input elasticity cannot be algebraically transformed to a MPP.

References

[1] ALCANTARA, REINALDO, "Returns to Scale and Resource Allocation in the Production of Sugarcane in Sao Paulo, Brazil," unpublished M.S. thesis, University of Florida, 1972.

[2] CLINE, W. R., *Economic Consequences of a Land Reform in Brazil*, Amsterdam, North Holland Publishing Co., 1970.

[3] DE JANVRY, ALAIN, "The Generalized Power Production Function," *Am. J. Agr. Econ.* 54:234–237, May 1972.

[4] DTEC-Copersucar, "Contribuicao aos Estudos de Reajustes de Precos para a Cano o Acucar e o Alcool," Sao Paulo, 1971.

[5] ETTORI, O. J. T., *et al.*, "Custo de Producao de Cana Industrial Produzida Pelos Fornecedores Cotistas em Sao Paulo," *Revista Agricultura em Sao Paulo* 15:33–54, 1968.

[6] *Folha de Sao Paulo* (newspaper), Ed. Folha de Manha, Sao Paulo, Brazil, Aug. 31, 1972.

[7] HILDEBRAND, J. R., "Some Difficulties with Empirical Results from Whole-Farm Cobb-Douglas-Type Production Functions," *J. Farm Econ.* 42:897–904, Nov. 1960.

[8] HOCH, IRVING, "Simultaneous Equation Bias in the Context of the Cobb-Douglas Production Function," *Econometrica* 26:566–578, Oct. 1958.

[9] KISLEV, YOAV, "Overestimates of Returns to Scale in Agriculture—A Case of Synchronized Aggregation," *J. Farm Econ.* 48:967–983, Nov. 1966.

[10] KMENTA, JAN, *Elements of Econometrics*, New York, The Macmillan Co., 1971.

[11] LAU, J. LAURENCE, AND PAN A. YOTOPOULOS, "Profit, Supply, and Factor Demand Functions," *Am. J. Agr. Econ.* 54:11–18, Feb. 1972.

[12] MORAES, FILHO, J. M., *Custo e Rentabilidade Para os Fornecedores de Cona de Acucar no Municipio de Piracicaba na Safra 1963–64*, Escola Superior de Agricultura, Luiz de Queiroz, Boletim Tecnico-Cientifico No. 25, Piracicaba, Sao Paulo, 1965.

[13] NERLOVE, MARC, *Estimation and Identification of Cobb-Douglas Production Functions*, Chicago, Rand McNally & Co., 1965.

[14] REVANKAR, N. S., "Production Functions with Variable Elasticity of Substitution and Variable Returns to Scale," Ph.D. thesis, University of Wisconsin, 1968, University Microfilms, Ann Arbor, Michigan.

[15] ULVELING, EDWIN F., AND LEHMAN B. FLETCHER, "A Cobb-Douglas Production Function with Variable Returns to Scale," *Am. J. Agr. Econ.* 52:322–326, May 1970.

[16] ZAGATTO, A., *et al.*, *Productivadade Marginal e Uso de Recursos na Labouro Canavierira no Municipio de Rio das Pedras Estado de Sao Paulo*, Escola Superior de Agricultura, Luiz De Queiroz, Boletim Tecnico-Cientifico No. 24, Piracicaba, Sao Paulo, 1964.

[17] ZELLNER, A., AND REVANKAR, N. S., "Generalized Production Functions," *Rev. Econ. Studies* 36:241–250, April 1969.

A Framework for Comparing the Efficiency of Futures Markets

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Empirical observation and theoretical analyses show that the allocative and forward pricing functions of futures markets are more reliable for continuous than for discontinuous inventory markets. This emphasis on the importance of carry-over inventory in affecting day-to-day price spreads is extended to take into account other factors which contribute to pricing efficiency. By examination of the characteristic behavior of the life cycle of a futures contract, a framework is developed to test, analyze, and contrast the performance of futures markets, i.e., how reliable futures quotations are as predictors of spot (cash) prices. Policy and theoretical implications are given.

IT HAS been estimated that 60 percent of agricultural commodity production in the United States in 1968 was represented by commodities having organized futures markets [11, p. 11]. Prices of some important internationally traded primary commodities are also determined via the futures market. Primary commodity prices are frequently volatile and unpredictable due to uncertainties in shifts of the supply and demand schedules. In this respect, futures markets play a stabilizing role in guidance of inventory and in stabilizing prices and incomes. It has been shown that well established and properly regulated futures markets are superior to cash markets in price determination because they provide central market prices established in open competitive bargaining, among other reasons [2]. Thus futures markets are important institutions in both domestic and international trade.

Price formation on futures markets at any point in time is the result of expert appraisal of past conditions, currently available information, and expectations on supply and demand. A viable futures market not only provides a constellation of prices which reflects available information on supply and demand, but also facilitates the carrying of inventories through hedging and hence reduces the variance of prices for the seasonally produced continuous inventory commodity. The performance of futures markets should be studied before domestic stabilization schemes or International Commodity Agreements are proposed and/or constructed for any commodity. Such study will assist in determining whether intervention in the market is desirable or will enable the design of better stabilization schemes. This aspect of the futures market literature has received relatively little attention.

The purpose of this paper is twofold. First, the study develops a framework to assess the efficiency of futures markets, drawing on and extending a recent work by Tomek and Gray [22]; second, an empirical application compares the relative performance of different markets and of the same market for different time periods.

Theory of Futures Markets and Market Performance

Most futures market literature emphasizes two important roles played by the market: guidance of inventory and establishment of forward prices. Price determination in futures markets has been explained through the theory of the "supply of storage," according to which the intertemporal price differences between spot and futures prices are related to inventory behavior over the time horizon. Working [26, p. 15] states that "expectations which deserve to influence the price of the most distant future quoted should always bear equally on spot prices, unless a period intervenes when stocks from both past and future production are expected to be non-existent." The "supply of storage" theory has been the basis of empirical studies in futures markets price determination [26, 4, 24, 15]. Tomek and Gray [22, p. 372] provide empirical evidence to show important basic differences in temporal price relationships between futures markets for commodities with "continuous" inventories (corn and soybeans) and futures markets for commodities with "discontinuous" inventories (potatoes).

According to Tomek and Gray, the discontinuity in potato stocks largely accounts for the absence of correlation between daily price quotations for the May and November futures; whereas, for corn and soybeans the daily price movement of near and distant futures has a high positive correlation, even when the com-

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modity is priced in different crop years [22, p. 377]. The Tomek and Gray hypothesis may be stated as follows: all things being equal, the allocative and forward pricing function of futures markets will be more reliable for continuous than for discontinuous inventory markets. This is so because when continuous inventories are carried, the daily price spread movements on all futures delivery months are affected "smoothly," interacting with inventory adjustments and contributing to pricing efficiency. This emphasis on the importance of carry-over inventory in affecting day-to-day price spreads may be extended to take into account other factors, such as the inherent difficulties in predicting demand and supply conditions and the institutions peculiar to the commodity in question. More specifically, the hypothesis may be restated and generalized to include other variables which contribute to pricing efficiency. Thus it is the carry-over together with the expected inventory behavior, the expectations on demand and supply conditions, and proper working of the futures institution—optimal level of speculation and hedging and proper regulations and by-laws—which impart to the established forward prices an aspect of "self-fulfilling prophecies." The forecasting performance of futures markets may then be compared and contrasted in terms of their forward pricing efficiency, i.e., how reliable the futures quotations are as predictors of the spot (cash) prices on a contract expiration date.

The "theory of anticipatory prices" [28], as developed by Working, emphasizes that prices are formed through human decision-making based on available information about supply and demand and past conditions on the market. The theory implies that price fluctuations in the market are due to expert appraisal of the significance of changing economic information in a world of uncertainty and this is the reason that day-to-day price quotations and fluctuations in a futures market exhibit a random walk characteristic. Statistically, the random walk hypothesis has been tested and in most cases found acceptable by Larson and others [17, 16, 21].[1]

Performance model criteria

Futures markets quotations reflect future conditions of supply and demand insofar as the current information and market conditions permit. The degree to which futures markets provide forward prices is more pronounced in the planting season because at this time future supplies are a matter of estimate, and the hedging use of the market is minimal. Thus, the "forecasts" (future prices) of the harvest time cash prices in the planting season may be used as indicators of how well the futures market is able to predict future market conditions. This may be formulated as the following simple linear regression equation:

$$P_H = \alpha + \beta P_{fH} + e_H,$$

where P_H = cash price at harvest time,

P_{fH} = previous futures quotations for harvest time contract,

and e_H = error term.

In this formulation the correlation coefficient, r^2, may be used as a measure of market performance. The higher the r^2, the more reliable the prediction. Furthermore, under ideal conditions, perfect information, and a "balanced market"—optimal hedging and speculation, and pure competition—a perfect "forecast" requires that the regression coefficients α and β be zero and unity respectively, and the expected value of P_H, given P_{fH} is equal to P_{fH}.

Empirical evidence of performance test

Price data were collected for Chicago wheat and Maine potato futures of the U. S. domestic markets. For each of these markets current prices (prices at expiration of the first futures after harvest) were regressed on the closing futures prices on the last day of trading of each month of the contract life for the period 1953 to 1969. Ordinary least-squares regression analysis was used to estimate the equations.

Table 1, in part, presents the empirical evidence supporting use of the r^2 as a measure of performance. The wheat market, a continuous inventory market, outperforms the potato market, a discontinuous inventory market that has relatively more pronounced uncertainties about conditions on supply and demand. The wheat market, unlike the potato market, provides more reliable estimates of forward prices at any point in time, although the potato market improves faster by virtue of starting from rela-

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[1] As pointed out, the "theory of anticipatory prices" has been investigated empirically through the random walk hypothesis. The hypothesis implies independence of futures price changes. This paper concerns itself with prices and not price changes. Thus, using standard regression methods in this study, the independence of the futures quotations will be sought through the Durbin-Watson test statistic.

Table 1. Estimated linear regression relationships between the spot (cash) price and prior futures price of the first futures after harvest, for wheat (July contract) and potatoes (November contract), 1953–1969[a,b]

Time interval[c]	Intercept		Slope		r^2		d.w.[f]	
	Wheat	Potatoes	Wheat	Potatoes	Wheat	Potatoes	Wheat	Potatoes
11[e]	55.67 (36.42)[d]	— —	.66 (.19)	— —	.44	—	1.76	—
10	34.29 (35.28)	479.62 (248.07)	.78 (.19)	−1.05 (1.05)	.53	.06	1.76	1.70
9	42.59 (35.86)	361.90 (246.94)	.73 (.19)	−0.54 (1.04)	.49	.02	1.69	1.90
8	32.18 (35.10)	−122.08 (212.28)	.78 (.19)	1.54 (0.92)	.54	.16	1.91	2.37
7	26.74 (31.92)	−186.29 (212.08)	.81 (.17)	1.84 (.93)	.61	.21	1.84	2.41
6	18.20 (30.13)	97.08 (144.62)	.86 (.16)	.59 (.62)	.65	.06	1.82	2.44
5	20.23 (28.89)	94.98 (88.33)	.85 (.15)	.61 (.38)	.67	.14	1.80	2.27
4	18.82 (26.08)	84.39 (58.14)	.87 (.14)	.67 (.26)	.72	.31	1.92	2.26
3	12.40 (22.70)	19.00 (45.24)	.92 (.12)	.96 (.20)	.78	.61	1.80	2.02
2	3.43 (20.83)	15.10 (37.21)	.98 (.12)	.97 (.16)	.83	.70	2.04	1.96
1	3.60 (14.99)	59.02 (29.73)	.99 (.08)	.77 (.13)	.90	.71	1.87	2.29

[a] The dependent variable—spot (cash) price—is the closing price on expiration of the July contract (wheat) and November contract (potatoes). The independent variable is the closing futures price of the same future recorded on the last day of preceding months. The variables are measured in cents per bushel for wheat and cents per hundredweight for potatoes.

[b] Data Source: *Wall Street Journal*, various issues.

[c] Time interval represents months in advance of contract expiration date.

[d] Numbers in parentheses are standard errors of the respective coefficients.

[e] For potatoes, in most years the market trading was not open that early; hence, quotations were not available 11 months prior to contract expiration date. This was also true of the soybean market.

[f] None of the Durbin-Watson Test Statistic results show a significant positive autocorrelation at the 1 percent level.

tively worthless estimates and approaches estimates that are perfect by definition.[3]

Test measure and analysis of performance results

Having confirmed the Tomek-Gray result and extended it to illustrate the characteristic behavior of a futures contract during its life cycle, the tests can be expanded by allowing for other market or institutional factors, in addition to the continuity of carry-over inventories. The test can be used to measure, compare, and contrast the performance of several futures markets. The above calculations were performed for cocoa and coffee, which are traded in international markets, and also for the soybean and corn markets in addition to wheat and potatoes, which have been used above to demonstrate the performance test measure.

Results of the performance test for the six commodities are shown in Table 2, which presents four sets of regression results. Each group presents the regression relationships between the spot (cash) price and prior futures price of the first futures contract after harvest, at the same time horizon away from the contract expiration date, for all commodity markets shown. The results are also charted in Figure 1.

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[3] Statistically, to ascertain whether the forecasts are unbiased and/or efficient, tests of sampling significance must be undertaken, i.e., a determination of whether the resulting regressions have intercepts which are not significantly different from zero, and slopes which are not significantly different from unity. Also, predictive reliability increases with higher values of r^2. This is especially valuable as one moves closer to the contract expiration date. The statistical results meet the criteria the closer one moves to the contract expiration date.

As predicted, the continuous inventory futures markets are relatively more reliable predictors of the spot (cash) prices than discontinuous inventory markets; the potato market has a lower r^2 compared to the other markets. Although the r^2 of the potato market increases as the contract expiration date is approached, it rises erratically and is not as high compared with the other markets.

The question now is how to account for the ranking in the performance test of the continuous inventory markets. For example, the r^2 for cocoa for the months reported in Table 2 and charted in Figure 2 is consistently lower relative to all the continuous inventory markets.

If the behavior of a market for two different periods is ranked or contrasted by using the

Table 2. Estimated linear regression relationships between the spot (cash) price and prior futures price of the first futures after harvest for potatoes, cocoa, coffee, soybeans, corn, and wheat, 1953–1969[a,b]

Commodity	Intercept	Slope	r^2	d.w.[f]	Intercept	Slope	r^2	d.w.
	10 months away from contract expiration date[e]				8 months away from contract expiration date			
Potatoes	479.62 (248.07)[c]	−1.05 (1.05)	.06	1.70	−122.08 (212.28)	1.54 (0.92)	.16	2.37
Cocoa	11.54 (6.74)	.67 (.23)	.35	1.27	8.38 (6.69)	.77 (.23)	.43	1.26
Wheat	34.29 (35.28)	.78 (.19)	.53	1.76	32.18 (35.10)	.78 (.19)	.54	1.91
Corn	20.30 (26.48)	.81 (.21)	.50	2.13	9.19 (27.21)	.89 (.21)	.54	1.97
Soybeans	10.76 (48.35)	.99 (.20)	.63	2.35	−14.42 (49.93)	1.09 (.20)	.66	2.08
Coffee[d]	−5.99 (11.06)	1.27 (.24)	.79	2.63	1.44 (7.05)	1.03 (.15)	.88	2.28
	6 months away from contract expiration date				2 months away from contract expiration date			
Potatoes	97.08 (144.62)	.59 (.62)	.06	2.44	15.10 (37.31)	.97 (.16)	.70	1.96
Cocoa	11.58 (5.20)	.65 (.17)	.49	1.39	1.62 (3.38)	.98 (.11)	.83	1.33
Wheat	18.20 (30.13)	.86 (.16)	.65	1.82	3.43 (20.83)	.98 (.11)	.83	2.04
Corn	−5.72 (23.27)	1.01 (.18)	.67	1.08	8.73 (9.52)	.93 (.08)	.91	0.79
Soybeans	4.57 (48.91)	1.02 (.20)	.63	1.50	−12.59 (25.40)	1.08 (.10)	.88	1.89
Coffee	17.73 (7.40)	.66 (.14)	.75	1.63	13.03 (4.46)	.74 (.08)	.92	1.77

[a] The dependent variable—spot (cash) price—is the closing price on expiration of the December contract (corn and cocoa), November contract (soybeans and potatoes), July contract (wheat), and September contract (coffee). The independent variable is the closing futures price of the same future recorded on the last day of preceding months. The variables are measured in cents per bushel for corn, soybeans, and wheat; in cents per pound for cocoa and coffee; and in cents per hundredweight for potatoes.

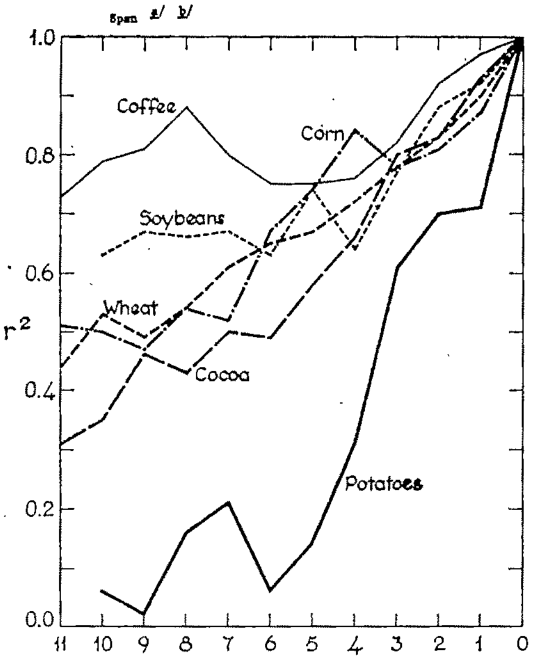
[b] Data Source: *Wall Street Journal*, various issues.

[c] Numbers in parentheses are standard errors of the respective coefficients.

[d] Based on 1953–62 only; 1963–69 excluded because of the Coffee Agreement.

[e] For cocoa, wheat, corn, and coffee the r^2 for 11 months away were .31, .44, .51, and .73, respectively. For soybeans and potatoes trading was not open that early in most years covered.

[f] With the exception of two values for the corn futures, none of the Durbin-Watson Test Statistic results show a significant positive autocorrelation at the 1 percent level.



a/ Data Source: Tables 1 and 2.

b/ Contrasting the r^2 Performance Test results for Potatoes, Cocoa, Wheat, Corn, Soybeans, and Coffee.

Figure 1. Predictive reliability behavior of a futures contract life span[a,b]

performance test, the "qualities" of several variables that contribute to pricing efficiency are being indirectly compared. These several independent variables are necessarily deduced from the conditions on the supply and demand sides and also the "quality" of the futures market institution pertaining to the nature of the commodity. Since the constellations of futures prices are arrived at after expert appraisal of changing economic conditions on demand and supply, it may now be hypothesized that given a *balanced*[3] futures market, optimal inventory allocation and forward pricing efficiency are a function of the following grouped variables taken together:

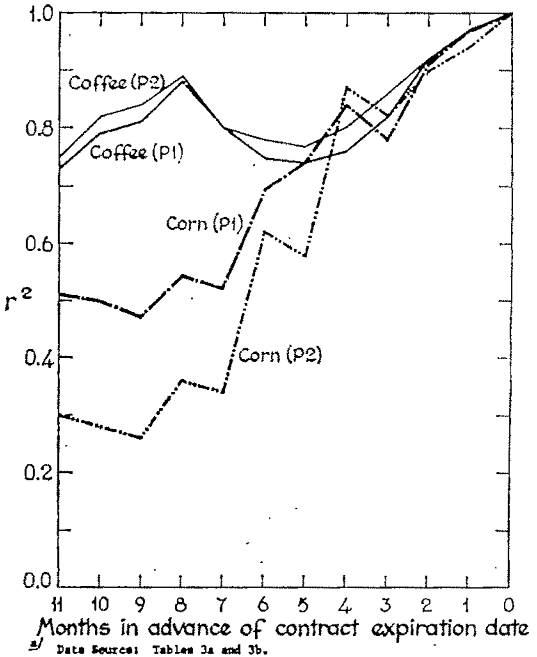
(1) The "nature" of the commodity, e.g., a continuous, quasi-continuous or non-inventory market; a perennial (tree) or annual crop and the degree of uncertainty in annual production variations; supply and demand elasticities; the nature of the stocks or inventory cost functions.

(2) The quality of information about past and forthcoming economic conditions on supply and demand and the ease of predicting these values adequately.

(3) The nature and degree of intervention by governments or international agencies in the free market price determination mechanism. All these known variables are reflected in the r^2 performance test.

Differences in variable emphasis

Tomek and Gray [22], in discussing temporal price relationships between futures markets, singled out and stressed the continuous inventory nature of a commodity as largely accounting for the contrasting forward pricing behavior between Maine potatoes, soybeans, and corn. Heifner [12], on the other hand, stressed government policies, e.g., price support programs, as being responsible for the contrasting behavior.[4]



a/ Data Source: Tables 3a and 3b.

b/ Contrasting the r^2 performance test results for corn for the periods 1953-1969 (P1) and 1953-1971 (P2), and for coffee for the periods 1953-1962 (P1) and 1953-1967 (P2).

Figure 2. Effects of policy and structural change on futures prices[a,b]

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[3] The concept of a "balanced" and/or "mature" futures market implies that the market neither overestimates nor underestimates prices over long periods of time. On the other hand, less well used markets, "thin" or "lopsided" markets may persistently overestimate or underestimate prices over extended time periods [10, p. 304].

[4] R. G. Heifner, commenting on the Tomek and Gray paper, stressed that the United States Government price support programs (and the attendant information about support levels) for corn, wheat, and soybeans account for the marked contrasting behavior between these commodities and potatoes. Tomek and Gray, in a reply to Heifner's paper, argue that support programs did not account for the contrasting behavior and that, moreover, soybean prices have been typically above support levels [12, 23].

In this paper the stress is upon the role played by the quality of information on inventory expectations in addition to the role played by inventories or carry-overs.[5] As pointed out, the r^2 performance test embodies all these groups of variables stressed above by different writers.

The r^2 performance test cannot be used to rank the commodities in absolute terms. For example, it is hard to answer the following question: To what extent is the quality of information about forthcoming economic conditions better for corn, wheat, and soybeans than for cocoa 10 months prior to harvest? If all the commodity markets presented here were similar in structure, with the same initial conditions and also were experiencing the same policies, then one could perform isolated tests of the ability to predict the effect of specific variables or policies and thereby rank the markets. Alternatively, these differences could be "corrected" using "weighted multiple regression" methods to contrast the performance of the markets. This methodology was not employed in the present study. Because the structure of the markets is different, only subjective statements can be made about the contrasting behavior using the r^2 performance test together with market structure analyses.[6] However, for the same market a policy, a variable, or a structural change can be isolated, and the effect of this change on the price determination mechanism can be noted by running the regression for two different time periods. This point may be demonstrated by extending the time period run for corn to incorporate structural change and that of coffee to reflect a policy change that took place.

Table 3. Comparison of estimated linear regression relationships between the spot (cash) price and prior futures price of the first futures after harvest, for corn (December contract) for periods 1953–1969 (P1) and 1953–1971 (P2)[a,b]

Time interval[c]	Intercept		Slope		r^2	
	Corn (P1)	Corn (P2)	Corn (P1)	Corn (P2)	Corn (P1)	Corn (P2)
11	27.11 (24.09)[d]	42.59 (30.37)	.75 (.19)	.65 (.24)	.51	.30
10	20.30 (26.48)	36.63 (33.02)	.81 (.21)	.68 (.26)	.50	.28
9	26.37 (26.51)	44.68 (34.42)	.76 (.21)	.63 (.26)	.47	.26
8	9.19 (27.21)	17.66 (34.18)	.89 (.21)	.84 (.27)	.54	.36
7	−12.32 (33.53)	−1.24 (42.24)	1.07 (.27)	.99 (.34)	.52	.34
6	−5.72 (23.27)	−15.66 (26.69)	1.01 (.18)	1.10 (.21)	.67	.62
5	9.16 (17.53)	8.81 (23.65)	.91 (.14)	.93 (.19)	.74	.58
4	12.50 (12.37)	8.85 (10.95)	.89 (.10)	.93 (.09)	.84	.87
3	13.67 (14.73)	7.58 (13.39)	.89 (.12)	.94 (.11)	.78	.82
2	8.73 (9.52)	1.13 (10.10)	.93 (.08)	.99 (.08)	.91	.90
1	9.48 (5.45)	2.29 (7.73)	.92 (.04)	.98 (.06)	.97	.94

[a] The dependent variable—spot (cash) price—is the closing price on expiration of the December contract for corn. The independent variable is the closing futures price of the same future recorded on the last day of preceding months. The variables are measured in cents per bushel.

[b] Data Source: *Wall Street Journal*, various issues.

[c] Time interval represents months in advance of contract expiration date.

[d] Numbers in parentheses are standard errors of the respective coefficients.

Evidence on structural and policy changes

Tables 3 and 4 and Figure 2 present the regression results for corn and coffee including time periods in which the degree of uncertainty in production variability was high and periods when there was a policy change. Changes of the r^2 performance test reflect these factors. Between 1925 and 1941 the corn crop typically ranged annually between 2 and 3 billion bushels; in 1934 and 1936 severe droughts caused crop sizes to drop to 1.4 and 1.5 billion bushels, respectively. Since 1941, annual crop variation has been normal. In 1970 a severe blight resulted in a small crop contrasting with good weather in 1971 which produced a bumper crop. The 1971 production was a record 5.5 billion bushels, 35 percent larger than 1970's blight-damaged crop and 16 percent above the previous high of 4.8 billion bushels. Unforeseen changes in weather conditions and the blight increased the uncertainties of supply forecasts. Consequently, the futures price prediction of the spot prices in these two years was relatively unreliable.

The case of coffee was different. In the late

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[5] Weymar [24, p. 1228] has restated the supply of storage theory. He stressed the role played by expected inventory behavior in accounting for intertemporal price spreads of futures quotations.

[6] Such an exercise is not fruitless, for it is possible to learn about the comparative weaknesses of other markets and seek to improve some institutions in the price determination mechanism. For example, a measure of the slopes in Figure 1—slope of the r^2's—may be used as an index for contrasting the *effectiveness of use* of market information for a commodity at different time intervals or periods. If the index is refined by "weighting" the variables, it could be used to contrast different markets.

Table 4. Comparison of estimated linear regression relationships between the spot (cash) price and prior futures price of the first futures after harvest, for coffee (September contract) for periods 1953–1962 (P1) and 1953–1967 (P2)[a,b]

Time interval[c]	Intercept		Slope		r^2	
	Coffee (P1)	Coffee (P2)	Coffee (P1)	Coffee (P2)	Coffee (P1)	Coffee (P2)
11	−3.18 (12.49)[d]	−6.17 (8.42)	1.20 (.28)	1.24 (.20)	.73	.75
10	−5.99 (11.06)	−9.80 (7.30)	1.27 (.24)	1.33 (.17)	.79	.82
9	1.14 (9.19)	−2.91 (6.09)	1.07 (.20)	1.13 (.14)	.81	.84
8	1.44 (7.05)	−1.47 (4.62)	1.03 (.15)	1.07 (.10)	.88	.89
7	11.04 (7.74)	7.44 (5.53)	.83 (.16)	.86 (.12)	.80	.80
6	17.73 (7.40)	13.72 (5.00)	.66 (.14)	.70 (.11)	.75	.78
5	15.91 (7.94)	11.52 (5.38)	.71 (.16)	.76 (.12)	.74	.77
4	14.52 (7.85)	9.78 (5.23)	.73 (.15)	.79 (.11)	.76	.80
3	13.52 (6.70)	9.99 (4.16)	.73 (.13)	.78 (.09)	.82	.86
2	13.03 (4.46)	9.47 (3.07)	.74 (.08)	.79 (.06)	.92	.92
1	−5.73 (3.78)	−3.81 (2.46)	1.14 (.07)	1.10 (.05)	.97	.97

[a] The dependent variable—spot (cash) price—is the closing price on expiration of the September contract for coffee. The independent variable is the closing futures price of the same future recorded on the last day of preceding months. The variables are measured in cents per pound.

[b] Data Source: *Wall Street Journal*, various issues. Note that a commodity agreement on coffee was ratified in 1962 and implemented in 1963. The futures market was almost dead by 1968. Thus 1968 and 1969 data are not included.

[c] Time interval represents months in advance of contract expiration date.

[d] Numbers in parentheses are standard errors of the respective coefficients.

1950's and early 1960's coffee supplies exceeded demand. Some producers, especially in Brazil, controlled their supplies and were somewhat successful in defending world floor prices.[7] In 1962 an international commodity agreement on coffee was negotiated and ratified, and it was implemented in 1963. Thus, during the period of this study coffee prices have been controlled in one way or another through export restriction agreements. As theorized, the r^2's for coffee (*P1*) and coffee (*P2*) are virtually the same, statistically, because prices were controlled in both periods. However, visually, there is a slight improvement in the case of coffee for the second time period, whereas the opposite is true in the case of the corn market. The above analyses demonstrate that the market structure must be studied before the r^2 performance test can be used to interpret the contrasting behavior of a market for different time periods or between markets.

Periodization of market performance

The cocoa market seems to exhibit some of the above contrasting features more sharply when investigated over a long historical period. The market was divided into three periods: the formative years, 1929–38; the war years, 1939–47; and the mature "balanced" period, 1948–69. The New York Cocoa Exchange was organized in 1925, and it was still growing in the first period when market information was not easily obtainable due to primitive communication networks. In the second period, market prices were administered to some extent as a result of World War II.[8] In the third period the New York Cocoa Exchange and the London Terminal Market grew rapidly into balanced markets [10]. The performance test applied to these periods conformed to expectations (see Table 5). The middle period performed best because prices were administered during the war years. In the formative period the performance was poor relative to the mature "balanced" period; this was more pronounced in the early phases of the contract life.

Contrasting the performance of commodity futures markets

In this section the r^2 performance test and other factors are used to contrast the relative behavior of futures markets. In non-inventory markets the futures market performs a forward pricing role. The forward pricing behavior re-

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[7] The time period covered for the r^2 performance test for coffee (Table 2) was from 1953 through 1962, excluding the period when ICA was in effect. However, for this period it may be said that prices were rigidly controlled as producers accumulated supplies to defend a floor price. In 1960, 3 million bags were allocated for industrial use in Brazil and 7 million bags were destroyed in mid-1961 [7, p. 111].

[8] At the outbreak of the Second World War the British government undertook to buy the total production of British West African cocoa, which accounted for well over 50 percent of world supply. In April 1940, Britain and France reached an accord for Britain to purchase the French West African crop and sell it abroad. Thus, the British controlled a large portion of world supply during the war period, and prices were controlled or administered. Specifically, the price of cocoa in the United Kingdom was controlled by the Ministry of Food from October 1, 1940, to November 1, 1950. In the United States there was a fixed ceiling price in New York for Ghanaian and Bahian cocoa of 8.9 and 8.7 cents, respectively, from 1942 to 1945.

Table 5. **Estimated linear regression relationship between the spot (cash) price and prior futures price, of the first futures after harvest for cocoa, for various historical periods—1929–1969**[a,b]

Time period	Intercept	Slope	r^2	d.w.[d]	Intercept	Slope	r^2	d.w.
	11 months away from contract expiration date				8 months away from contract expiration date			
Period I, 1929–38	4.14 (2.44)[c]	.29 (.32)	.10	2.26	2.97 (2.53)	.51 (.37)	.19	2.20
Period II, 1939–47	−3.02 (3.45)	1.72 (.34)	.78	2.01	−6.31 (3.98)	2.06 (.41)	.79	1.88
Period III, 1948–69	16.02 (7.03)	.46 (.24)	.16	1.50	13.72 (5.57)	.56 (.20)	.29	1.57
	6 months away from contract expiration date				2 months away from contract expiration date			
Period I, 1929–38	1.05 (2.67)	.81 (.40)	.34	2.03	−.86 (1.21)	1.23 (.20)	.83	2.05
Period II, 1939–47	−.89 (2.9)	1.38 (.26)	.80	2.05	3.01 (1.35)	.75 (.08)	.92	2.47
Period III, 1948–69	13.38 (4.55)	.56 (.15)	.39	1.78	5.03 (3.69)	.83 (.12)	.70	1.23

[a] The dependent variable—spot (cash) price—is the closing price on expiration of the December contract. The independent variable is the closing futures price of the same future recorded on the last day of preceding months. The variables are measured in cents per pound.

[b] Data Source: *Wall Street Journal*, various issues.

[c] Numbers in the parentheses are standard errors of the respective coefficients.

[d] None of the Durbin-Watson Test Statistic results show a significant positive autocorrelation at the 1 percent level.

flects a great deal of uncertainty on expectations concerning supply. On the other hand, in the continuous inventory markets there is a linkage between futures contracts via the supply of storage which helps to make the futures prices self-fulfilling prophesies. In this case the markets continuously adjust equilibrium prices to new market information, and the "quality" of this information becomes the crucial factor. Thus, continuous inventory futures markets can be expected to outperform quasi-continuous and non-inventory markets, in that order. The potato market has a lower year-to-year variation in production (instability index), but because of its discontinuous nature, it provides less reliable spot price forecasts (Table 6 and Fig. 1).[9]

Contrasting the behavior of continuous inventory markets is not so clear-cut. However, by identifying important variables such as degree of crop production variation, isolating them, and analyzing their effects on the pricing behavior, qualitatively or quantitatively, conclusions regarding their responsibility for the contrasting behavior can be drawn.

Figure 2 shows that the coffee futures market out-performs all other markets. It has the highest r^2 almost throughout the contract life. As noted for the period under study, 1953–62, supply was consistently greater than demand, and producers began accumulating stocks to defend a floor price. In the United States the year-end carry-over inventory steadily increased. Prices could not rise under these conditions. Futures prices and spot prices fluctuated downward within a narrow band—hence, the high predictive reliability.

It is difficult to account for the contrasting behavior between the United States grain markets; the r^2 performance test differences are not pronounced for the grains. A more sensitive model will have to take into account the effects of the government support programs for the period under study, as well as the nature of the commodities.[10]

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[9] Lower price elasticity of demand also imparts higher instability to potato prices. The present study did not include measurements of this contrasting behavior.

[10] For the grains, the contrasting behavior may not be related to quality of information about production and demand. We have good information in the United States for the grains, but we still have uncertainties about planted acreage and yields. Hence, we cannot be specific about crop size, say ten months prior to harvest. However, it seems that more is known about soybeans than wheat or corn between ten and five months prior to harvest (Fig. 1 and Footnote 4).

Table 6. Instability index for yearly changes in production, 1953–1969[a]

Commodity	Three year moving average percentage deviation method	Yearly percentage deviation method
Potatoes	4.11	6.69
Cocoa (imports)	6.30	12.23
Wheat	6.76	10.66
Corn[b]	4.36 (4.95)	7.55 (8.74)
Soybeans	3.87	9.46
Coffee (imports)[c]	4.36	8.10

[a] The formulas for measuring the instability indexes are described in [8, Ch. 2].

[b] The values in parentheses show the instability index for corn for the period 1953–1971. In 1970 there was a corn blight (small crop), but 1971 was a bumper crop year.

[c] The index for coffee is based on the period 1953–1962. See text concerning exclusion of later years.

Among the continuous inventory markets studied, cocoa performs relatively poorly. Relative to the grain inventories, cocoa appears less responsive to price relationships.[11] Thus, smooth inventory adjustments to a forthcoming crop size cannot be expected to the same extent obtainable for grains. This is certainly true for the producers who cannot store the commodity for over a year, and true to some extent of the middlemen and consumers in temperate zones. Secondly, the uncertainties about forthcoming crop size are less and the quality of information about economic conditions are better for United States grains than for cocoa. Table 6 shows that cocoa has a higher production instability index than the grains. Year-to-year production change commonly exceeds 30 percent. Production forecasts for cocoa, a perennial crop, are relatively inaccurate.[12] On the other hand, forecasting the production of seasonal crops such as corn, wheat, and soybeans is relatively easy. Additionally, in the United States, decision makers in these markets enjoy relatively accurate information, furnished by the United States Department of Agriculture, on crop estimates and weather forecasts.

Uncertainty surrounding cocoa forecasts at the beginning of a new season is reflected in nearby futures as well as in distant futures and manifests itself in the low predictive reliability of the spot prices by the futures prices [25]. It may be hypothesized that the relatively poor performance of the cocoa futures market is probably due to the lower responsiveness of the inventories and lack of adequate information on supply and demand conditions, especially the degree of uncertainty surrounding supply forecasts.

Implications and Conclusions

The above analysis has demonstrated the effects of different grouped variables other than inventories on forward pricing efficiency. The study seems to suggest a generalized version of Holbrook Working's price of storage theory and Brennan's supply of storage theory which attempt to explain intertemporal price spreads in terms of existing inventories alone [4, 26, 27].[13] Specifically, the supply of storage theory can be viewed as a partial theory of a generalized information theory that takes into consideration the other variables which have been shown to contribute to pricing efficiency.[14] This view is essential now because futures markets, which historically first emerged for annual crops that could be stored continuously, are now being organized for non-inventory commodities, to help allocate resources optimally and stabilize prices and incomes, by establishing forward prices.

In most developed countries proposals for stabilizing producer incomes have ranged from price support programs to efficient use of the futures markets by farmers or by official agencies trading futures contracts on behalf of farmers [18, 13]. Some economists accept the desirability or "goodness" of price and income stabilization [19, 5, 15]. As a consequence, a large body of literature on price and income stabilization of primary products, especially in less developed countries, has been produced since World War II. However, most stabilization schemes interfere with the proper functioning of futures markets. Yet the introduction of futures contracts as an aid in price determination, in addition to the cash markets, adds positive dimensions in competition by enlarging the sphere of price making forces and providing insurance against risks by projecting market commitments months in advance of contract expiration dates. It is therefore surprising that very little empirical work has been done to analyze how well futures markets perform the important functions of guidance of inventory and establishment of forward prices and hence indirectly stabilizing price and incomes.[15]

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[11] Cocoa is produced in the tropics and consumed primarily in the temperate zones. The commodity cannot be stored in the tropics for over a year under normal conditions. It deteriorates because of moth and Lasioderma infestation. As far as the producers are concerned, cocoa may be said to be a "quasi-continuous inventory" product [6, pp. 76–78, 129–132].

[12] Production forecasts for most perennial or tree-crops are inaccurate. Quantitative attempts at estimating the supply function for cocoa have not proved very successful [20, 1, 3].

[13] Holbrook Working, recognizing the predominant importance of the continuous inventory variable in accounting for intertemporal price spreads, has remarked: "The results from all lines of investigation concur in indicating that prices quoted at one time, in a futures market, for two different dates of delivery, stand in a relation which in general *does not* reflect expectations regarding events that may occur between the two delivery dates. This conclusion holds whether the dates lie in separate 'crop years,' . . . or in the same crop year" [27, p. 1255].

[14] The information theory approach was underscored in Robert Dorfman's discussion of the efficiency of the "price system": "An enormous number of bits of information are compressed into a simple sign like '73¢/lb.' posted above a display of meat or a line such as 'Wheat, No. 2 and hard K.C. bu. . . 2.20' on the financial page" [9, p. 7].

Contrasting the performance of several futures markets is an instructive and useful exercise. For example, by pinpointing the variables that contribute to pricing efficiency and that are lacking in a particular market, policy instruments to make the market more viable could be devised, e.g., design of better price stabilization schemes. Also, the effects of various price support programs can be analyzed. The effectiveness of use of market information can be quantified.

This paper began with the widely held intuitive concept that there is a direct correlation between the price of a future at the time of its expiration and the price of that future several months prior to expiration. The study has demonstrated that futures markets perform their forward pricing function very well and that the correlation coefficient, the performance test statistic, measures well the degree to which the spot (cash) price is predictable months in advance for a particular commodity. The present model allowed an empirical view of the characteristic behavior of the life cycle of a futures contract. It showed that the predictive reliability of a futures market improves as more accurate information on supply and demand becomes available. Thus price formation in the market reflects expert appraisal of the significance of changing economic information in a world of uncertainty.

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[15] On the other hand, there is an impressive list of theoretical work which has been done on the theory of forward markets. See, for example, "A Symposium on the Theory of Forward Markets," which features articles by Kaldor, Dow, and Hawtrey [14]. Also see articles by Working, Cootner, Telser, and Gray presented at a recent symposium on "Price Effects of Speculation in Organized Commodity Markets" [29].

References

[1] Ady, Peter, "Trends in Cocoa Production," *Bull. Oxford Univ. Inst. Stat.* 2:389–404, Dec. 1949.

[2] Bakken, Henry H., "The Factors Favoring a Futures Contract for Live Hogs Outweigh Those Against it," in *Futures Trading in Livestock Origins and Concepts*, ed. Henry H. Bakken, Madison, Wisconsin, Mimir Publishers, Inc., 1970.

[3] Bateman, M. J., "Aggregate and Regional Supply for Ghanaian Cocoa," *J. Farm Econ.* 47:384–401, May 1965.

[4] Brennan, M. J., "The Supply of Storage," *Amer. Econ. Rev.* 48:50–72, March 1958.

[5] Chandler, W., and A. McArthur, "Efficient Equalization Funds for Farm Prices," *Am. J. Agr. Econ.* 50:91–110, Feb. 1968.

[6] Chatt, Eileen M., *Cocoa*, New York, Interscience Publishers, Inc. 1953.

[7] *Commodity Yearbook 1969*, New York, Commodity Research Bureau, Inc., 1969.

[8] Coppock, J. D., *International Economic Instability*, New York, McGraw-Hill Book Company, Inc., 1962.

[9] Dorfman, Robert, *The Price System*, Englewood Cliffs, Prentice Hall, Inc., 1964.

[10] Gray, Roger W., "The Characteristic Bias in Some Thin Futures Markets," *Food Res. Inst. Stud.* 1:296–324, Nov. 1960.

[11] Gunnelson, J. A., "A Study of the Impact of Organizational Changes in Agricultural Commodity Markets on Futures Markets," unpublished thesis, Purdue University, 1970, quoted in Henry B. Arthur, *Commodity Futures as a Business Management Tool*, Cambridge, Harvard University Press, 1971.

[12] Heifner, R. G., "Temporal Relations Among Futures Prices: Comment," *Am. J. Agr. Econ.* 53:361–362, May 1971.

[13] Houthakker, Hendrik S., *Economic Policy for Farm Sector*, Washington, D. C., American Enterprise Institute, 1967.

[14] Kaldor, N., *et al.*, "A Symposium on the Theory of Forward Markets," *Rev. Econ. Stud.* 7:195–205, 1939–40.

[15] Kofi, Tetteh A., "International Commodity Agreements and Export Earnings: Simulation of the 1968 'Draft International Cocoa Agreement,' " *Food Res. Inst. Stud.* 11:177–201, 1972.

[16] Labys, W. C., and C. W. J. Granger, *Speculation, Hedging and Commodity Price Forecasts*, Lexington Mass., D. C. Heath and Co., 1970.

[17] Larson, Arnold B., "Measurement of a Random Process in Futures Prices," *Food Res. Inst. Stud.* 1:313–324, Nov. 1960.

[18] Lermer, G., "The Futures Market and Farm Programs," *Canadian J. Agr. Econ.* 16:27–30, June 1968.

[19] Meade, J. E., "International Commodity Agreements," *Lloyds Bank Review*, July 1964.

[20] Stern, Robert M., "The Determinants of Cocoa Supply in West Africa," in *African Primary Products and International Trade*, eds. I. G. Stewart and H. D. Ord, Edinburgh, Edinburgh University Press, 1965.

[21] Stevenson, Richard A., and Robert M. Bear,

"Commodity Futures: Trends or Random Walks," *J. Finance*, 25:65–81, 1970.

[22] Tomek, W. G., and R. W. Gray, "Temporal Relationships Among Prices on Commodity Futures Markets: Their Allocative and Stabilizing Roles," *Am. J. Agr. Econ.* 52:372–380, Aug. 1970.

[23] ———, "Temporal Relations Among Futures Prices: Reply," *Am. J. Agr. Econ.* 53:363–366, May 1971.

[24] Weymar, F. Helmut, "The Supply of Storage Revisited," *Am. Econ. Rev.* 56:1226–1234, Dec. 1966.

[25] ———, *The Dynamics of the World Cocoa Market*, Cambridge, M.I.T. Press, 1968.

[26] Working, Holbrook, "Theory of the Inverse Carrying Charge in Futures Markets," *J. Farm Econ.* 30:1–28, Feb. 1948.

[27] ———, "The Theory of the Price of Storage," *Am. Econ. Rev.* 39:1254–1262, Dec. 1949.

[28] ———, "A Theory of Anticipatory Prices," *Am. Econ. Rev.* 48:188–199, May 1958.

[29] ———, *et al.*, "Proceedings of a Symposium on Price Effects of Speculation in Organized Commodity Markets," *Food Res. Inst. Stud.*, Supplement to Vol. 7, 1967.

Opportunity Cost of Time and Other Socioeconomic Effects on Away-From-Home Food Consumption*

FRED J. PROCHASKA AND R. A. SCHRIMPER

Viewing the household as both a producing and consuming unit suggests the opportunity cost of the homemaker's time to be an important factor affecting food consumption. Opportunity cost of time is shown empirically to have a positive affect on away-from-home consumption for employed homemakers in all 12 region-urbanization classes studied. The same response is shown for unemployed homemakers in most classes. Furthermore, the estimated bias associated with income elasticities estimated without adjustment for the time input was significant in most cases. Estimated effects of income, family composition and size, and race on away-from-home food consumption are analyzed.

THE growing affluence of American households is often cited as an important factor increasing the demand for the variety of foods and services offered by eating-out establishments. The trend in personal per capita away-from-home food and beverage expenditures over the last 20 years has been substantially upward, especially during the mid- and later 1960's. During this period, per capita expenditures increased from \$83 in 1951 to \$141 in 1970.[1] This trend appears to be consistent with estimates from the 1955 and 1965–66 USDA Household Food Consumption Surveys [6]. After adjustment for price changes, however, away-from-home expenditures per capita exhibit a slight decline over the two decades. In terms of market shares, there has been a rather sharp decline in the proportion of total personal food and beverage purchases adjusted to 1967 prices being spent in the away-from-home market as illustrated in Figure 1.[2]

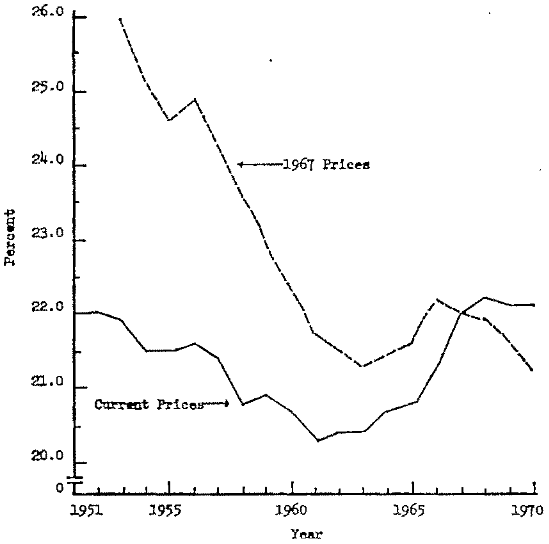

Figure 1. Away-from-home consumption as a percent of total personal food and beverage purchases, current and 1967 prices, 1951–1970*

* The away-from-home shares of the market in terms of 1967 prices were calculated by deflating away-from-home expenditures by the retail price index for food away from home (1967 = 100) and expenditures for home use by the retail price index for all food eaten at home (1967 = 100). The price index for away-from-home expenditures is not available for years prior to 1953.

At first glance, the trend in market shares appears to be quite different from what one might expect based on generally assumed differences in income elasticities of demand for food consumed at home relative to away from home. For example, estimates by Hiemstra and Eklund [5] and Burk [3] suggest that the income elasticity of expenditures for food away

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[1] These data represent the value (including taxes and tips) of food and beverages (including alcohol) purchased from retail, service, and amusement establishments, hotels, dining and buffet cars, schools, school fraternities, institutions, clubs, and industrial lunchrooms calculated by the Office of Business Economics in the U. S. Department of Commerce as reported in [10, 11]. Expense account expenditures and value of food furnished commercial and government employees are excluded. A good discussion of alternative estimates of aggregate expenditures for food away from home is presented by LeBovit [6].

[2] Essentially the same pattern was observed when expense account expenditures obtained directly from the Office of Business Economics, U. S. Department of Commerce, were added to the numerator and denominator. The away-from-home share of total purchases increased, but the same pattern was observed over the 20-year period.

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from home is considerably higher and perhaps twice the elasticity for at-home food consumption expenditures. Such differences in elasticities have generally been accepted as consistent with what is known about the income elasticity of demand for marketing services [12]. A higher income elasticity of demand for food away from home relative to at home, however, suggests that the share of the total personal food budget spent for food away from home would increase with increased income levels, *ceteris paribus*. As noted above, especially after adjusting for price changes, the away-from-home share has actually decreased over the last twenty years. This apparent inconsistency between market shares and income elasticity differences suggested that either specification errors may have affected previous income elasticity estimates or there have been sufficient changes in other factors, including relative price changes, to have more than offset any differential income effects.

In recent economic literature, increased attention has been given to the value of time as a determinant of household production and consumption behavior through the theoretical contributions of Becker [1] and others. Furthermore, Mincer [7] in several empirical examples has shown that estimates of the income elasticity of demand for several commodities are biased when the opportunity cost of time is ignored. In view of these contributions to the theory of household behavior, it was decided to examine the effects of including a measure of the opportunity cost of homemaker's time in a model explaining cross-sectional variation among households in away-from-home food consumption. This approach permitted estimates to be made of the possible specification bias in the effects of income that would have resulted had value of time been excluded from the model. The remaining parts of this paper include a model of demand for cross-sectional analysis of away-from-home food consumption, the estimates obtained from the 1965–66 USDA Household Food Consumption Survey, and the estimates of the specification bias associated with the income coefficients that would have occurred in the absence of opportunity cost of time being considered.[3]

The Model

The household production-consumption model consists of four principal components: a utility function, a household production function, a time input constraint for the homemaker, and an income constraint. Using these four components along with specific assumptions concerning their form and omitting the subscript for households, the following demand function was specified:[4]

$$(1)\quad Y_1 = B_0 + B_1(I + wT) + B_2(P_1a_1 + t_1w) + B_3(P_2a_2 + t_2w)$$

where

$Y_1 =$ the number of meals purchased and consumed away from home per unit of time (week),

$I + wT =$ the full income of the household per unit of time; I represents all income accruing to the household other than wage income of the homemaker; wT represents the homemaker's total time, T (time spent in the labor force plus the time spent in producing consumption goods), valued at the market wage rate, w,

$P_1a_1 + t_1w =$ sum of the market price (P_1a_1) and the nonmarket price (t_1w) of Y_1, where P_1 is a vector of prices of market inputs used to produce Y_1, a_1 is a vector of input coefficients used in the production of Y_1, and t_1 is a vector of time inputs coefficients used in the production of Y_1,

$P_2a_2 + t_2w =$ sum of the market price (P_2a_2) and the nonmarket price (t_2w) for the alternative meal consumed at home (Y_2), a_2 and t_2 are vectors of input and time coefficients, respectively.

The demand function (1) may be expressed in terms of observable money income of the household by considering the time input constraint which is written as

$$(2)\quad T = T_w + T_c = T_w + \sum_{i=1}^{n} T_i$$

where T represents total time available, T_w represents time spent in the labor market earning money income, and T_c represents total time spent in production of consumption goods, $1, \cdots, n$. For purposes of this study, the time input constraint is assumed to represent the time of the homemaker or wife.[5] Division of her total time is general and is not meant to assume that all time is spent actively at work in the labor force and/or in the home producing goods and services as these are normally viewed. Leisure, recreation, and other activities enter into T_c and are also considered as economic goods. Substituting equation (2) for T in equation (1) and collecting terms results in the following expression containing observable money income of the household:

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[3] For a more complete description of the entire study, see Prochaska [8].

[4] For a complete development of equation (1), see [8] and [1].

$$Y_1 = B_0 + B_1M + B_2(P_1a_1) + B_3(P_2a_2) + B_4w \tag{3}$$

where $M=(I+wT_w)$ and $B_4=(B_1T_c+B_2t_1+B_3t_2)$.

An analysis of the elements comprising B_4 suggests there is reason to suspect that this coefficient might be different for homemakers employed outside the home compared to those who were not employed outside the home (hereafter referred to as unemployed homemakers). This is largely because the values of T_c would be expected to differ between these two groups of homemakers considering the nature of equation (2) and assuming all homemakers have the same amount of total time available to allocate either to the production of household goods or spend in the labor market. For this reason, the model was specified to permit a differential effect for B_4 depending on whether or not the homemaker was employed outside the home.[6] As customary for normal cross-sectional analysis, it was assumed that all households face the same level of market prices for goods and services (constant P_1 and P_2 among households). It was further assumed that the input coefficients (a_1 and a_2) did not significantly vary among households, meaning that the B_2 and B_3 effects would be confounded with B_0. Finally, composition, size, and racial characteristics were added as additional explanatory variables to reflect possible sources of variation in away-from-home eating among households. The culmination of these considerations and addition of an error term resulted in the following model for estimation:

$$\begin{aligned} Y_1 = B_0' &+ B_1M + B_{41}w + B_{42}wE \\ &+ B_{51}C_1 + B_{52}C_2 + B_{53}C_3 \\ &+ B_{61}P_1 + B_{62}P_2 + B_{63}P_3 + B_{64}P_4 \\ &+ B_7F + B_8O + B_9N + \epsilon \end{aligned} \tag{4}$$

where $B_0'=B_0+B_2P_1a_1+B_3P_2a_2$; $E=0$ if homemaker is employed and 1 if unemployed; C_1, C_2, and C_3 are 0–1 variables for 1, 2, and 3 or more preschool-age children, respectively; P_1, P_2, P_3, and P_4 are 0–1 variables for 1, 2, 3, and 4 or more school-age children, respectively; F represents the total number of individuals in the household; O and N are two 0–1 variables used to represent households classified in the two racial categories of "other" and Negro (where O and N equal zero if the household is white); and ϵ is an error term assumed to satisfy all the necessary conditions to produce BLUE estimates.

Data

For purposes of obtaining estimates of the parameters in the above model for away-from-home food consumption, individual household information collected in the Spring portion of 1965–66 USDA Household Food Consumption Survey was used. Insofar as dependent variables were concerned, the survey indicated the number of meals the household reported purchasing away from home during the survey week as well as the total expenditures related to these meals. Reported expenditures on meals away from home included tips and taxes. These were the two major dependent variables used throughout the analysis although additional analyses were undertaken using the number of noon meals purchased as well as total expenditures on food away from home including the value of snacks. Since the original sample for this survey was selected to enable the data to be classified by regions and urbanizations, these geographical and place of residence distinctions were maintained throughout this study. Separate sets of parameters were estimated for each of the three urbanization classifications within each of the four basic regions of the United

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[5] Although other individuals in the household may assist in meal preparation, the assumption that T represents only the homemaker's time does not appear to be too unrealistic. A study by K. E. Walker [13] of households in the city and suburbs of Syracuse, New York, reported that over 70 percent of the total time spent on household activities was the homemaker's time. In addition, the homemaker contributed 68 to 85 percent of the total time spent on food-related activities. Amount of time spent on household activities was found to be inversely related to the number of hours the homemaker spent in the labor force.

[6] Conceptually, there might be several gradations in B_4 related to varying intensities of working outside the home. A dichotomy in these effects is consistent, however, with the data used for subsequent estimation which reported labor force participation only for those homemakers employed 35 or more hours per week for pay outside the home.

States.[7] Since a major thrust of this investigation concerned the opportunity value of homemaker's time, observations were deleted in cases where the household was identified as containing no homemaker. Observations were also deleted if certain key pieces of information concerning household's income, race, and homemaker characteristics were missing. Households without homemakers and missing information resulted in 675 of the original 7,532 observations being omitted from the analysis. Since an alternative market wage rate was used to compute a value of time for each homemaker as explained below, the sample was further restricted to those households with homemakers less than 65 years of age. This factor led to the deletion of an additional 938 observations resulting in 5,919 total observations being used in the final estimation.

Information was available from the survey to calculate readily the values for all independent variables in equation (4) except for the wage rate.[8] Wage rates were not available for homemakers in the survey data and therefore had to be estimated exogenously.[9] Estimates of the alternative net market wage rates ranged from \$.07 to \$2.80 per hour for the homemakers in this sample.

Results

The multiple regression results of estimating the coefficients in equation (4) with the dependent variable being the weekly total number of meals purchased away from home are presented in Table 1 for the 12 region-urbanization groupings. The explanatory power as indicated by the R^2 value adjusted for sample size was between 17 to 28 percent for most of the groups. The one case in which a considerably higher adjusted R^2 resulted was for the group with the fewest number of observations. Each of these groups had from 48 to 67 percent of households reporting one or more meals eaten away from the home.

About the same degree of overall explanation occurred in the case of analyzing the number of noon meals eaten away from home, and slightly lower degrees of explanation occurred in the cases where expenditures were used as dependent variables. Examination of the residuals suggested that the model fitted equally well at all values of income and wage rates and furthermore indicated no reason to reject any of the classical assumptions about the error terms. Table 1 indicates a number of coefficients were relatively large compared to their standard errors. There was little difference in the relationship between the size of the coefficients and the standard errors among the four different forms of the dependent variables studied, even though some differences in magnitude of coefficients were observed. Important differences will be noted below although the full set of results will be presented for only the dependent variable representing total meals eaten away from home. Particular emphasis will be given to discussing the coefficients of the income and wage rate variables, consistent with the main interests of the analysis.

Income effects

All of the coefficients of the income variable in Table 1 are positive, consistent with families with higher incomes eating more meals away from home than families with low incomes. In all cases, the partial effects of income differences were significantly larger than the respective standard errors for the urban households, but not in the case of the farm households. An even more consistent pattern in differences of the income effects between urban and rural households was observed when expenditures for all meals were used as the dependent variable. This can be observed from the elasticity estimates presented in Table 2 which indicate that for each of the four regions, expenditure elasticities are highest for urban households and

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[7] Precise definitions of the urbanization classifications and geographical delineations are provided by USDA [9].

[8] Mid-points of income intervals were used in calculating values for the income variable, and values for the two extreme income classes were obtained in private communications with the Economic and Statistical Analysis Division of the Economic Research Service, USDA.

[9] The estimated parameters and the associated estimates of standard errors (in parentheses) are:

$$\begin{array}{lllll} w = -2.2534 & - \ .0697S & + \ .0104S^2 & + \ .1760A & - \ .0023A^2 \\ & \quad (.0905) & \quad (.0037) & \quad (.0335) & \quad (.0004) \end{array}$$

where S and A represent years of schooling and age, respectively. Parameters relating wage rates for females to levels of education and age were estimated from a weighted cross-sectional regression analysis of wage rates per hour for female workers in 310 occupational classifications reported in the 1960 Census. The intercept of this relationship was adjusted to predict accurately the average wage rate for the female labor force in 1965. These coefficients were then used to predict a market alternative wage rate based on reported age and schooling level for each of the homemakers in the 5,919 households. A proportional adjustment was applied to the predicted wage rates to reflect the effects of income taxes, before using the values for estimation of parameters in equation (4).

Table 1. Partial regression coefficients and standard errors[a] for all meals purchased away from home by households by urbanizations within regions

Region and urbanization	Adjusted R^2	Partial regression coefficients and standard errors												
		Income[b]	Wage rate		Number of preschool age children			Number of school age children				Family size	Race	
		b_1	Employed homemakers b_{41}	Employment interaction b_{42}	One b_{51}	Two b_{52}	Three or more b_{53}	One b_{61}	Two b_{62}	Three b_{63}	Four or more b_{64}		"Other"	Negro
Northeast														
Urban	.19	.49 (.06)	1.51 (.53)	−.94 (.31)	−2.45 (.63)	−4.12 (.89)	−6.98 (1.31)	−.05 (.64)	−1.00 (.85)	−3.46 (1.19)	−4.83 (1.65)	1.44 (.29)	1.90 (1.11)	.39 (.62)
Rural nonfarm	.10	.17 (.12)	.22 (1.14)	−1.98 (.62)	1.13 (1.31)	.73 (1.99)	.14 (3.27)	−.21 (1.45)	3.71 (1.87)	8.73 (2.71)	5.11 (3.60)	−.51 (.70)	—	—
Farm	.17	.18 (.20)	2.48 (2.27)	−2.51 (1.45)	1.44 (2.00)	−4.01 (2.87)	−6.77 (4.63)	−1.92 (2.20)	−2.06 (3.00)	1.64 (3.25)	2.23 (4.37)	1.16 (.74)	—	—
North Central														
Urban	.20	.44 (.06)	1.52 (.54)	−.34 (.32)	−3.24 (.65)	−4.75 (.98)	−7.72 (1.45)	−.00 (.71)	.25 (.93)	−1.62 (1.21)	−4.15 (1.81)	1.71 (.32)	.96 (1.78)	.36 (.75)
Rural nonfarm	.19	.44 (.16)	.25 (.97)	−.64 (.52)	−2.48 (1.12)	−3.52 (1.69)	−3.72 (2.80)	2.46 (1.17)	4.07 (1.62)	4.49 (2.29)	6.16 (3.22)	.53 (.63)	—	—
Farm	.28	.11 (.09)	2.82 (.80)	−1.75 (.54)	−3.22 (.98)	−4.43 (1.51)	−8.83 (2.07)	−.71 (1.02)	1.39 (1.38)	−.65 (1.74)	−.57 (2.46)	2.55 (.46)	—	—
South														
Urban	.22	.28 (.07)	2.79 (.53)	−1.81 (.33)	−2.04 (.73)	−3.62 (1.04)	−3.99 (1.64)	.15 (.69)	.87 (1.04)	1.22 (1.33)	−1.96 (1.94)	1.79 (.35)	−.33 (2.64)	−1.41 (.60)
Rural nonfarm	.19	.40 (.10)	1.90 (.92)	−1.85 (.55)	−2.49 (1.06)	−4.94 (1.48)	−9.85 (2.25)	1.55 (1.11)	2.19 (1.33)	−.13 (1.91)	−1.51 (2.48)	1.74 (.43)	−6.09 (3.58)	−.12 (1.23)
Farm	.25	.12 (.08)	1.58 (.64)	−.65 (.44)	−.64 (.79)	−2.30 (1.28)	−1.52 (1.76)	3.35 (.83)	5.37 (1.05)	8.20 (1.40)	8.02 (1.92)	.28 (.34)	−1.75 (2.22)	−4.42 (.77)
West														
Urban	.24	.31 (.07)	2.08 (.63)	−1.04 (.36)	−2.91 (.81)	−4.83 (1.35)	−7.14 (2.07)	−.09 (.87)	1.66 (1.22)	−1.21 (1.63)	−3.47 (2.39)	1.83 (.44)	−.18 (1.25)	−.56 (.91)
Rural nonfarm	.43	.24 (.23)	8.70 (2.15)	−7.24 (1.24)	−1.57 (2.42)	−3.05 (3.66)	−1.88 (5.40)	−5.37 (3.57)	−4.56 (3.95)	−.60 (4.97)	−4.27 (6.30)	1.99 (1.37)	2.99 (2.76)	—
Farm	.18	.06 (.11)	3.14 (1.74)	−1.87 (1.18)	−7.09 (2.31)	−11.17 (2.60)	−18.50 (3.94)	−4.98 (1.81)	−6.90 (2.58)	−10.43 (3.53)	−18.43 (4.98)	4.92 (1.07)	−10.90 (4.06)	—

[a] Standard errors are in parentheses.
[b] Expressed in units of 1000 dollars.

Table 2. **Quantity and expenditure income elasticities for meals consumed away from home, by urbanizations within regions**[a]

Region	Urbanization		
	Urban	Rural nonfarm	Farm
Northeast			
Quantity	.61	.22	.20
Expenditure	.79	.61	.51
North Central			
Quantity	.58	.49	.10
Expenditure	1.16	.99	.26
South			
Quantity	.26	.37	.10
Expenditure	.81	.78	.48
West			
Quantity	.40	.29	.09
Expenditure	.84	.80	.31

[a] Elasticities are computed at the mean values for respective variables.

lowest for rural households. The expenditure elasticities in Table 2 are generally less than Hiemstra and Eklund's [5] estimate of .84 for the aggregate United States. The rural nonfarm and farm estimates in Table 2 tend to be lower than Hiemstra and Eklund's for these two groups, but the opposite is true in the case of the urban group.

A comparison of the quantity and expenditure elasticities for a given region-urbanization category in Table 2 indicates that higher income households tend to purchase more "quality" and "services" or at least higher priced meals. In every case, the expenditure elasticity is larger than the corresponding quantity elasticity with the difference being smallest nearly always in the case of the farm households. Furthermore, the differences imply that the quality elasticity is larger than the quantity elasticity in all but one or two cases.

The quantity-income elasticities for noon meals were generally 30 to 60 percent smaller than the corresponding coefficients for the quantities of all meals reported in Table 2 implying quite high elasticities for evening and/or morning meals. The latter were not estimated in this study because of the large proportion of nonpurchasing households in the sample. An analysis of the income coefficients when the dependent variable was total expenditures for just meals compared to the results when expenditures included the cost of snacks as well as meals indicated that in 10 of the 12 cases, the imputed income elasticity for snacks was less than .38.

Opportunity cost of time

Households in which employed homemakers have a high opportunity cost of time tend to consume more meals away from home than households with homemakers whose opportunity cost of time is low. This is indicated by the positiveness and size of B_{41} relative to the standard errors in Table 1. The effects of increases in the opportunity cost of time of homemakers who were not employed outside the home were also generally positive, but considerably smaller than for employed homemakers. The estimated effects for households with unemployed homemakers are obtained by adding the estimate of B_{41} and B_{42} for a given region and urbanization consistent with the way this differential effect was specified in equation (4). In nine of the 12 cases, a positive response for unemployed homemakers was indicated, and coefficients quite close to zero occurred in two of the other three cases.[10] Most of the coefficients representing the effects for employed homemakers indicate approximately 1.5 to 3 more meals eaten away from home per week by households with homemakers whose value of time is $1.00 per hour higher. On the other hand, the same difference in value of time among unemployed homemakers is associated with around .5 to 1.5 extra meals per week away from home for most of the cases where positive responses were present.

Another way the difference in effects of opportunity cost of time between employed and unemployed homemakers is observable is in terms of value-of-time elasticities reported in Table 3. These coefficients represent the percentage change in the number (or expenditures) of meals eaten away from home associated with a 1 percent increase in the value of homemaker's time, *ceteris paribus*.[11] In nearly every case the coefficients for the unemployed homemakers are less than the corresponding coefficients for the employed homemakers. The value-of-time elasticities generally are larger than income elasticities for farm households but smaller in the case of urban and rural nonfarm households except in the West. Another characteristic of the value-of-time elasticities is that in only about 50 percent of the cases was the expenditure elasticity larger than the corresponding quantity elasticity. Except in the West, farm households were the most consistent in terms of purchasing additional quality and/or services with increasing value of homemaker's time. The sharp contrast in the relationship of the quality-quantity elasticities in the case of income and value of time is consistent with theoretical results reported in [2].

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[10] There is an implied assumption throughout this discussion that the employment status of the homemaker is not altered. If an increase in the value of homemaker's time encourages more homemakers to become employed, then the effect on away-from-home consumption would be greater than the response for either group.

[11] These elasticities cannot be interpreted in terms of what would happen if the opportunity cost of homemaker's time increased as a result of changes in the general wage level. If wage rates increase, prices of away-from-home meals and food products for at-home consumption are likely to change, affecting consumption behavior.

Table 3. Quantity and expenditure value-of-time elasticities for meals consumed away from home by urbanizations within regions for households with employed and unemployed homemakers[a]

Region and urbanization	Households with homemakers			
	Employed		Unemployed	
	Quantity	Expenditure	Quantity	Expenditure
Northeast				
Urban	.30	.36	.15	.32
Rural nonfarm	.04	−.02	−.54	−.64
Farm	.43	.80	−.01	.84
North Central				
Urban	.37	.18	.30	.10
Rural nonfarm	.06	.05	−.11	−.17
Farm	.56	.71	.26	.52
South				
Urban	.50	.34	.21	.16
Rural nonfarm	.35	.25	.01	.07
Farm	.32	.45	.23	.31
West				
Urban	.48	.59	.30	.68
Rural nonfarm	1.04	.99	1.02	.21
Farm	.72	.42	.43	.20

[a] Elasticities are computed at the mean values for respective variables

Family composition, size, and racial effects

Other coefficients in Table 1 represent the estimated effects associated with differences in family composition, size, and racial characteristics. By holding family size constant, the coefficients of the variables representing the number of preschool and school age children indicate the estimated effects of differences in family composition. The predominance of the negative coefficients for the preschool age children variables means that the presence of preschool age children instead of adults tends to reduce the number of meals eaten away from home. The composition effect of pre-school age children is generally larger than the effect of an increase in family size suggesting that the addition of a preschool age child to a household might actually reduce the total number of meals eaten away from home. On the other hand, the composition effect of school age children (6–18 years of age) is not so clear in terms of the mixture of positive and negative coefficients. Some of the differences between effects of preschool and school age children may be the results of school lunch programs, differences in the need for baby sitting services, and older children in the school age group possibly participating in activities leading them to eat away from home. Effects of the school lunch program appeared to be particularly evident in the analysis of noon meals where more than 80 percent of the coefficients for the presence of school age children were positive. Estimates of B_7 suggest that especially among urban households an extra adult (18 or more years old) in the household would be responsible for around 1.5 to 2.0 extra meals away from home per week. As the number of family members of this age increase in a given household, there is likely to be additional eating away from home because of employment or social activities. In addition, the meals of college students living away from home were recorded as away-from-home consumption for purposes of this survey.

The racial variables indicated that Negro and "other" households generally tended to consume fewer meals away from home than white households in the South and West, but slightly more in the Northeast and North Central.[12] The negative coefficients may reflect the effects of differences in tastes and preferences, previous discrimination by eating-out establishments, or occupational differences.

Analysis of Specification Bias Effects

To consider further the effects of including the opportunity cost of time on the income coefficients for away-from-home consumption, estimates were made of the specification bias that would have resulted if the opportunity cost of time had not been considered. These estimates were computed assuming the only differences between the true model and the misspecified model are the two variables involving wage rate of the homemaker. The expected value of the income coefficient in the misspecified model can be shown to equal $B_1+D_1B_{41}+G_1B_{42}$ in which D_1 represents the coefficient of the income variable in the linear relationship between w and all the other independent variables in the

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[12] In certain region-urbanization categories, there was not a sufficient number of households of particular races to justify estimating separate racial effects.

Table 4. Estimated specification bias associated with income coefficients if opportunity cost of homemaker's time excluded for different measures of food away from home by urbanizations within regions[a]

Region and urbanization	Dependent variables							
	Aggregate meals		Noon meals		Expenditures on meals		Expenditures on meals and snacks	
	Amount[b]	Percent[c]	Amount[b]	Percent[c]	Amount[b]	Percent[c]	Amount[b]	Percent[c]
Northeast								
Urban	.0612***	12	.0554**	16	.0843***	12	.0976***	13
Rural nonfarm	−.0431	−25	−.0300	−36	−.0449	−12	−.0338	−9
Farm	.0487	27	.0329	50	.0676**	22	.0654*	13
North Central								
Urban	.0448***	10	.0281**	11	.0179	2	.0155	2
Rural nonfarm	.0171	4	.0106	4	.0126	2	.0602***	10
Farm	.0469**	44	.0259*	471	.0441***	28	.0472***	24
South								
Urban	.0870***	31	.0630***	38	.0458**	7	.0496**	7
Rural nonfarm	.0641	16	.0684	46	.0345	6	.0442	7
Farm	.0601**	51	.0355*	88	.0476*	16	.0554**	13
West								
Urban	.0749***	24	.0632***	39	.1210***	18	.1307***	18
Rural nonfarm	.2288***	96	.1856***	227[d]	.1265**	26	.1595**	31
Farm	−.0104	−16	−.0083	−361	−.0030	−2	.0031	4

[a] Confidence levels of .90, .95, and .99 are noted by *, **, and ***, respectively.

[b] Amount refers to the number of meals or expenditure per week by households for a $1,000 change in family income (after taxes).

[c] Percent refers to the amount of bias relative to the unbiased estimates of the income coefficients.

[d] This reflects the relative change based on absolute value of the unbiased elasticity.

misspecified model. Similarly, G_1 represents the coefficient of the income variable in the linear relationship of the other variable involving the opportunity cost of homemaker time (wE) on the remaining independent variables in the misspecified relationship.[13] The amount of bias associated with coefficients of the income variable was calculated based on the estimates of B_{41} and B_{42} presented in Table 1 along with partial regression coefficient estimates of D_1 and G_1 obtained from linear relationships of the particular opportunity cost of time variables on the other independent variables.[14]

The results of estimating these biases in the income coefficients are shown in Table 4 for each of the four dependent variables used in this study. The estimates indicate that the biases are consistently positive implying that substantially higher, and in many cases significantly higher, coefficients of the income variable would have been obtained if opportunity cost of time had not been included as an explanatory factor. The biases are larger in absolute value for the urban household but larger in percentage terms for the farm households because of the smaller size of the income coefficients for the latter group. In nearly 90 percent of the cases, the relative bias was greater than 10 percent.

Conclusions

The results of this study suggest that variation in prices associated with value of homemaker's time are an important variable in cross-sectional analysis of food consumption, especially if unbiased estimates of the effects of other variables are desired. This also implies that additional effort ought to be made in future surveys to consider ways to measure more directly the value of homemaker's time to avoid having to use an indirect procedure to impute values as was the case in this study.

Inclusion of the opportunity cost of time resulted in lower estimates of income elasticity for away-from-home eating than what would have been obtained in its absence. Even though it is often not appropriate to use cross-sectional estimates for time series inferences, it appears evident that the magnitude of the reduction does not help very much to explain the trends in market shares during the last two decades.[15] Therefore, changes in other factors must have been sufficient to offset any differential income effects.

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[13] This development closely parallels the discussion in Goldberger [4, pp. 194–197].

[14] Estimating the bias in this way is equivalent to calculating the differences in estimates of the income coefficients for regressions in which the variables involving the homemaker's opportunity cost of time are included and excluded. The advantage of the former approach, however, is that it leads more directly to estimating the variance of the bias for purposes of statistically testing the null hypothesis about the degree of bias.

A much broader framework than the individual household model used in the above cross-sectional analysis seems to be required to understand all the factors affecting away-from-home food consumption over time. For example, little is known about the cross price elasticities of eating at home and away from home. Nevertheless, the fact that away-from-home prices have been increasing nearly twice as fast as prices for all food eaten at home since 1953 certainly would be expected to have had a significant influence on relative market shares over time. This also suggests the significant influence differential rates of technical change and elasticities of substitution between labor and capital in different segments of the food production and marketing system could have on away-from-home food consumption over time. Increased availability of convenience foods and additional mechanical labor-saving kitchen equipment might have important effects in reducing the required amount of homemaker's time in meal preparation, thereby reducing the opportunity cost component of the full price of eating at home. Changes in technology and differential elasticities of substitution appear to be extremely relevant in considering the impact of rising wage rates on away-from-home food consumption over time. These factors underlie possible differential effects on the market price component as well as the opportunity cost component of the full price of alternative food commodities the household can select to produce and consume.

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[15] Two additional qualifications need to be considered in making any generalization about the entire U. S. population based on this study insofar as eating away from home is concerned: (1) the exclusion from the original USDA sample of all households in which no members ate 10 or more meals at home during the survey week, and (2) the criteria that were employed in further deleting particular households to permit special attention to be given to the effects of the opportunity cost of time as described earlier.

References

[1] BECKER, G. S., "Theory of the Allocation of Time," *Econ. J.* 75:493–508, Sept. 1965.

[2] ———, AND H. G. LEWIS, "On the Interaction Between the Quantity and Quality of Children," *J. Pol. Econ.* 81:279–288, March–April 1973.

[3] BURK, M. C., *Food Expenditures by Upper Income Families*, Minnesota Agr. Exp. Sta. Tech. Bull. 269, 1969.

[4] GOLDBERGER, A. S., *Econometric Theory*, New York, John Wiley & Sons, Inc., 1964.

[5] HIEMSTRA, S. J., AND H. M. EKLUND, "Food Expenditures in 1960–61," *National Food Situation*, USDA NFS-117, 1966, pp. 37–47.

[6] LEBOVIT, C., "Expenditures for Food Away From Home," *National Food Situation*, USDA NFS-122, 1967, pp. 42–48.

[7] MINCER, J., "Market Prices, Opportunity Costs, and Income Effects," in *Measurement in Economics*, ed. Carl Christ, Stanford, California, Stanford University Press, 1963, pp. 66–82.

[8] PROCHASKA, F. J., "Opportunity Cost of Time and Other Socioeconomic Effects on Away-From-Home Food Consumption," unpublished Ph.D. thesis, North Carolina State University, Raleigh, 1970.

[9] U. S. Department of Agriculture, Agricultural Research Service, *Household Food Consumption Survey, 1965–66*, Reports 1–5, 1968.

[10] U. S. Department of Agriculture, Economic Research Service, *Food Consumption, Prices, and Expenditures*, Agricultural Economic Report No. 138, U. S. Government Printing Office, Washington, D. C., 1968.

[11] ———, *Food Consumption, Prices and Expenditures*, Supplement for 1970 to Agr. Econ. Rep. 138, 1971.

[12] WALDROF, W. H., "The Demand for and Supply of Food Marketing Services: An Aggregate View," *J. Farm Econ.* 48:42–60, Feb. 1966.

[13] WALKER, K. E., "Time Used by Husbands for Household Work," *Family Economic Review*, USDA ARS 62-5, 1970, pp. 8–11.

Short Articles and Notes

Undergraduate Program Revision at Kansas State University*

JOHN SJO, FRANK ORAZEM, AND ARLO BIERE

This article reports the Kansas State experience in extensive revision of its undergraduate educational program. Revision was based on student, faculty, alumni, and employer participation. The new curriculum gives new emphasis to behavioral sciences and analytical techniques which better prepare students for agribusiness jobs.

KANSAS State University has made a comprehensive revision of its undergraduate agricultural economics program, as have other universities. It was found that much of today's educational experience prepared students inadequately for life or employment. Rapid technological and cultural changes are bringing a future that requires new approaches to education [2, 6]. Although most faculty and administrators have the best intentions, their revisions of educational programs often have been stunted by budgetary constraints, individual resistance to change, and the morass of academic politics. This article reports the procedures and results of one experience in educational revision.

At Kansas State University, curriculum revision, accomplished piece-meal, resulted in a well intended but largely obsolete agricultural economics major in the curriculum of agriculture. Because agricultural economics students are the only social science oriented students in the College of Agriculture, they have been required to conform to a college curriculum oriented to students in the applied biological and physical sciences. The unique scholastic base of agricultural economics was recognized over the years in piece-by-piece concessions and footnotes to the curriculum.

To consolidate the gains from and to replace the piecemeal process of curriculum revision, the Department of Agricultural Economics began in 1970 a one-year undergraduate program review that involved faculty, students, administrators, employers, and alumni. The review resulted in a new curriculum and a revision of course offerings with several traditional courses in agricultural economics dropped. The new curriculum increased requirements in social sciences, business administration, quantitative methods, and communications, and reduced requirements in physical and biological sciences. Course revision reduced duplication among courses, introduced new subject matter, deleted obsolete subject matter, provided theoretical courses earlier in the program, introduced courses specifically for nonmajors, and increased the number of analytical upper division courses. Course revision was made within the constraint there would be no increase in total major courses offered; any new major course was offset by dropping one. This restraint did not apply to the two new general education courses—*Economics of Population, Food, and Environment* and *Rural Poverty*.

The Revision Process

The authors were appointed to a special review committee responsible for conducting an undergraduate program review and proposing curriculum and course revisions. The committee's first step in evaluating the existing program was to determine groups which should be involved in such an evaluation. Figure 1 identifies groups with a vital interest in the program: the faculty and university administrators, students (including alumni), employers, and society as represented by the board of regents, the legislature, and the press. Traditionally, curriculum development has been the responsibility of the faculty and university administrators. This review was an attempt to break that tradition because a successful curriculum must be sensitive to all those with identified interests. The information-gathering phase sought to identify the concerns of each group and to determine the extent of commonality of their

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interests (represented by subspace A in Fig. 1). To receive support from all groups, a curriculum ought to include but not be confined to A. It was anticipated by the committee that including inputs from all interested groups would produce a curriculum that would more nearly meet the tests of those interested in undergraduate agricultural economics education. By including all four groups in the revision process, not only is the curriculum different, but also there is a new and broader prospective for all the interested parties, as shown by an expanded area A in Figure 1.

Student input came from recorded information from personal interviews with all graduating seniors over several years, a comprehensive alumni survey, and a special student review committee whose members frequently joined the faculty committee as it prepared its findings and recommendations. Employer views came informally from personal contacts by faculty among employers who hire Kansas State University graduates. Society's interests were identified from subjective evaluations, based on public statements of legislators, regents, and citizens as reported in the press, of current social and economic trends. Faculty input from other departments was through conferences with representatives from other departments, particularly those using agricultural economics for service courses.

From the evaluation by the above listed four groups, the committee developed a set of educational objectives to guide development of program revisions. Suggested revisions are intended to fulfill the educational objectives defined. A report on the evaluation findings, educational objectives, and suggested revisions was prepared for students and faculty. A two-day departmental seminar provided faculty and student representatives an opportunity to review and react to the committee's report. The review committee then prepared a report that ncorporated the seminar input and presented t to the departmental faculty, which approved t with minor changes. The proposed new curriculum and course revisions were unanimously approved by the college faculty and were subsequently approved by the University Faculty Senate and the Board of Regents, effective March 1, 1972.

Review Findings

During its deliberations the committee identified several major developments not specifically mentioned by the groups surveyed. Many students now entering college have completed accelerated primary and secondary educational programs. University educational programs must be structured to challenge and stimulate such students. One approach is to encourage wider use of credit by examination as provided by College Level Examination Program (CLEP) to avoid requiring students to cover material they already have mastered. Eventually, many well prepared students may be able to complete the baccalaureate degree in three years [1].

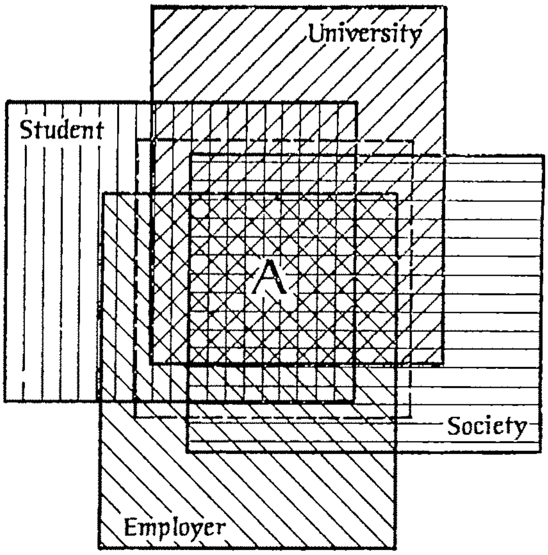

Figure 1. **Curriculum development model identifying groups affected by and involved in course and curriculum revision**

A portion of the youth entering the university, however, will be from economically disadvantaged groups whose secondary school preparation precludes their competing with those from accelerated programs and who have quite a different set of expectations concerning education. Developing educational experiences responsive to the needs of both groups is a challenge of the 1970s. Although many will seek education outside the College of Agriculture, their rural background undoubtedly will cause some to enroll in agriculture. As the only social science department in the college, agricultural economics should accept a heavy responsibility for the education of the rural disadvantaged.

Structural changes in higher education begun in the 1960's will continue in the 1970's. Common education will be extended beyond secondary education, and two-year community colleges will be the primary vehicle for many. Universities can expect a higher percentage of new students to have completed two years in a community college. Adjustments are needed in courses and curricula to help those students reach their potential.

Universal higher education will increase the total cost of education. It will necessitate developing more economical instructional techniques while maintaining quality instruction. Ever increasing numbers of students and pressure to lower per student costs will result in further mass treatment of students unless new ways to treat each student as a significant individual are found.

The land grant concept of combining research, extension, and instruction in academic departments has been basic to agricultural education. When conceived and initiated, research emphasis was on developing improved production techniques and was closely related to what was offered in undergraduate instruction programs. Under such conditions there was a wide range of complementarity between undergraduate teaching and research. Gradually, as research became narrower, more complex, and more sophisticated, the complementarity between it and undergraduate instruction declined. Today it may have only an indirect beneficial effect of "keeping up to date." Undergraduate instruction may complement research even less. There also appears to be little complementarity between undergraduate instruction and extension.

The faculty, students, and employers agreed that present program flexibility allowing students some latitude on nearly one half their course requirements should be retained. Employers, alumni, and faculty stressed increasing communications skills. Employers expressed interest in a combination of farm-reared experience and education in technical agriculture, business, and economics with emphasis on understanding the national economy. Dobson and Matthes reported similar findings [4].

Employment opportunities for agricultural economics graduates are mainly in agribusiness and agriculture-related government agencies. Opportunities in farm production continue to decline. Graduates increasingly compete with liberal arts and business administration graduates. Consequently, their needs for management and agribusiness instruction have increased. Students called for a sharper distinction between agricultural economics and the technical agriculture curriculum. Department faculty supported this position and requested that agricultural economics have a curriculum separate from the curriculum of agriculture.

Faculty and students agreed that the repetition of subject matter among courses should be reduced and that new subject matter such as agricultural law and macro-economic topics should be added. Students said courses should be more practical and more devoted to problem solving. The faculty felt the problem solving capabilities of the majors could be improved by moving more theoretical courses from the senior to the junior year so seniors could apply theory to actual problems in the senior year.

Responding to comments of faculty in other departments, the agricultural economics faculty agreed that more courses should be introduced as a service to nonmajors. Faculty favored continuing the strong advising program that treats each student as a worthy individual, identifies his interest and abilities, and assists him in achieving his goals. Faculty members were concerned about the impact of increasing class size on quality of instruction, and noted a need for improved instructional, student study, and computational facilities. Finally, the faculty recognized that they design and implement curriculum and courses according to their experiences. The result is that undergraduate instruction often is best suited for those planning to enroll in graduate studies, whereas its chief recipients are the terminal B.S. graduates.

Educational Objectives

Educational objectives that guided the final revision of curriculum and courses are summarized here. The fundamental objective of an educational program is to bring about a change in the individual student with regard to facts he knows and understands, skills and techniques he can use, judgment and ability to make decisions, concepts of what ought to be, and a style of life. Since differences in interests, abilities, and previous experiences among students are so great, highest levels of learning can occur best if the university educational experience is designed so each individual is enabled to develop his full potential [3].

To assume that each student has the opportunity and stimulation to prepare for a profession and an enriched personal life, any curriculum should:

(1) Provide the basis for a general educa-

tional experience that encourages the student:

  - (a) To develop an understanding and an appreciation of his environment through study of the sciences—physical, biological, behavioral—and the humanities.
  - (b) To develop an understanding of how values and value systems develop and change.
  - (c) To develop a desire for, and skills to, pursue individual independent study.
  - (d) To develop analytical skills through study of mathematics, logic, and research methods.
  - (e) To develop communication skills by studying and practicing writing and speaking.

(2) Provide the basis for professional training that encourages the student:

  - (a) To develop a desire and ambition to excel in his profession and to understand the requirements and rewards expected in the profession.
  - (b) To develop competence as an agricultural economist able to identify economic problems, to analyze relevant information, and to propose solutions for economic and social problems.
  - (c) To develop analytical skills that will be useful for a professional lifetime. (Each student must be provided with a basis for his top professional performance two or three decades after graduation.)

The interests of the agricultural economist have sprung, not from a single branch, but from two branches of knowledge, the bio-physical sciences underlying agricultural production and the socioeconomic sciences underlying economic organization of agriculture [7]. One problem a curriculum in agricultural economics must deal with is alloting course credits between those two branches of knowledge. The balance needed will vary from student to student, so the curriculum's rigidity should be minimal to assure flexibility and opportunities for individual student programs of study that give different weights to the two branches.

Few matriculating students have identified their career alternatives. Many use their first semesters for career analysis. Therefore, specialization that reduces student mobility among departments should be delayed as long as possible. Such delay becomes even more necessary as more students receive their first two years of higher education at community colleges. The first, and even second year, should provide opportunities for a student to explore alternative curricula or programs of study. The faculty should assist each student in finding the educational experience that will do most to fulfill his needs and objectives.

No curriculum, regardless of how well conceived, can assure excellence in the educational experience of the students. A curriculum is no guarantee of excellence in course content or in quality of instruction, either in the classroom or in the advising program. Efforts in curriculum improvement must be equally supported in course improvement, instructional improvement, and advising improvement.

Program Revisions

The new curriculum in agricultural economics identifies a core of general education courses to be taken the first two years of a student's college work (see Table 1 for the specific listing). Biological and physical science requirements were reduced; communications requirements were increased.

Principles of Agricultural Economics and *Economics II* (introductory micro-economic theory taught in Arts and Sciences) are treated as fulfilling the same role—an introduction to micro-economic issues. Work in macro-economics was increased to include six semester hours of intermediate course work oriented toward public economic issues such as income and employment theory, money and banking, natural resource economics, labor economics, etc. To assure that all students have a sound background in microeconomic principles, students are enrolled in the one-year sequence, *Production Economics* and *Agricultural Market Structures*, during their junior year. This series is taught at the intermediate level using elementary calculus and relying heavily on applying theory to real situations. The sequence provides the student with a conceptual base that allows him to work more effectively in the applied and analytical courses offered at the senior level. All students are required to enroll in at least one of the department's problem oriented courses (*Price Analysis*, *Quantitative Methods in Agricultural Marketing Firms*, *Economic Analysis of Farm Firms*, *Bargaining and Cooperation*, *Natural Resource Economics*, *Rural*

Table 1. Curriculum requirements for the agricultural business option, Department of Agricultural Economics, Kansas State University, 1972

GENERAL EDUCATION			
Should be taken in first two years and are recommended for all junior college students considering majoring in agricultural economics			
Social Science:	*Credit Hours*	*Science:*	*Credit Hours*
Economics I	3	Principles of Biology	4
Principles of Political Science	3	General Chemistry	5
General Psychology	3		
Introduction to Sociology	3		9
Principles of Agricultural Economics[1]	3	*Math:*	
		College Algebra	3
	15		
Communications:			
English Composition I	3	*Humanities:*[3]	6
English Composition II	3		
Oral Communications I	2		
Electives[2]	6		
	14		
Total General Education			47
PROFESSIONAL EDUCATION			
Should be taken at Kansas State University in the last two years			
Agricultural Economics:		*Business Administration:*	
Production Economics	3	Fundamentals of Accounting	4
Agricultural Market Structure	3	Electives[2]	9
Economics of Agricultural Business	3		
Electives[1]	12		13
	21	*Agriculture:*[3]	12
Math-Stat-Computer Science:	6		
		Public Economic Policy:[3]	6
Total Professional Education			58
ELECTIVES			
General Electives:[3]			21
Total for graduation			126

[1] Economics II may be used.
[2] Selected from list approved by the department.
[3] Choice of student, with not more than one half from one discipline.

Human Resource Development). The computer science requirement recognizes the expanding role of computers in business and society.

Jones, Lard, and Manderscheid [5] found quantitative analysis to be under-utilized in undergraduate teaching. Because of credit hour limitations and faculty reluctance to include calculus in the curriculum, it was decided to incorporate elementary calculus into the production economics courses. This was found to be a necessary intermediary step in upgrading the quantitative work.[1]

Business administration is now more heavily emphasized with requirements ranging from 4 to 13 hours according to the option selected. Requirements of the agribusiness option are shown in Table 1.[2] Requirements for options in farm management, professional economics, and agricultural programs differ only in the mix of professional courses.

Another significant revision in the program was in course offerings. A list of current course offerings is presented in Table 2. Two new courses—*Economics of Population, Food, and Environment* and *Rural Poverty*—are offered at the freshman level to all students in the university. Both courses were deemed worthwhile; also, it was believed that the university's responsibility for providing the courses fell to the Department of Agricultural Economics. *Principles of Agricultural Marketing*, *Land Economics*, *Principles of Cooperation*, and *Agricultural Finance* were judged no longer meaningful in their present forms. They were dropped with the subject matter included in new courses.

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[1] In June 1973, after this article was accepted for publication, the department took the next step by making *Introduction to Analytical Processes* (mathematics for economics and business) a curriculum requirement and a prerequisite for *Production Economics*.

[2] Option at K.S.U. refers to specialization within a curriculum with all options sharing a common core of requirements. Major refers to the department affiliation of the student.

Agricultural Market Structures is devoted to alternative forms of agricultural market organizations, regional specialization, and trade. Some traditional topics in agricultural marketing considered less important today have fallen by the wayside. *Land Economics* had combined the study of land as a natural resource and the problem of acquiring land as a production factor. *Farm Resource Acquisition and Finance* now is devoted entirely to acquiring production inputs including capital and land. *Natural Resource Economics* concerns the management of land and other natural resources for highest social returns. *Consumption Economics*, *Economics of Food Marketing*, and *Agricultural Law and Economics* were added to fill voids perceived in course offerings.

Applied and quantitative courses added were *Bargaining and Cooperation*, *Rural Human Resource Development*, *Price Analysis*, *Quantita-*

Table 2. Course offerings in agricultural economics before and after revision, Kansas State University, 1972

Old Listing	New Listing
INTRODUCTORY UNDERGRADUATE COURSES	
**Grain Marketing	*Principles of Agricultural Economics
**Livestock Marketing	**Economics of Population, Food, and Environment
*Principles of Agricultural Economics	**Rural Poverty
Farm Management	
Farm Planning Laboratory	
Rural Banking	
Principles of Agricultural Marketing	
Agricultural Economics Summary	
Agricultural Economy of South Asia	
UNDERGRADUATE COURSES (May carry graduate credit for nonmajors)	
International Agricultural Development	Production Economics
Agricultural Policy	Agricultural Market Structures
Consumption Economics in Agriculture	Agricultural Policy
Agricultural Prices and Market Structures	Consumption Economics in Agriculture
Economic Principles of Agricultural Business Firms	Farm Management
Land Economics	Farm Resource Acquisition in Agriculture
Agricultural Finance	Economics of Food Marketing
Principles of Cooperation	International Agricultural Development
Agricultural Economic Statistics	Agricultural Law and Economics
	Rural Banking
	Economic Principles of Agricultural Business Firms
	Agricultural Economic Statistics
	***Grain Marketing
	***Livestock and Meat Marketing
	***Ranch and Feedlot Management
	Bargaining and Cooperation
	Natural Resource Economics
	Principles of Transportation
	Rural Human Resource Development
GRADUATE COURSES (May be taken for undergraduate credit)	
Production Economics	Price Analysis
Land and Resource Conservation	Quantitative Methods in Agricultural Marketing Firms
Principles of Transportation	Economic Analysis of Farm Firms
****GRADUATE COURSES	
Advanced Farm Management	
Price Analysis	

* Required of most College of Agriculture students.
** Service courses may not be used to meet major course requirement.
*** Primarily service courses, majors may take one.
**** Partial listing showing only courses changed from graduate to lower level.

tive Methods in Agricultural Marketing, and *Economic Analysis of Farm Firms*. The last three are the most quantitative of the set of applied courses and rely heavily on concepts covered in the junior year sequence of microeconomics.

Grain Marketing, *Livestock Marketing*, and *Ranch and Feedlot Management* are primarily service courses for other majors in the college of agriculture. *Economics I* is their only prerequisite; hence they are less suited to the needs of majors in agricultural economics. However, a student showing strong interest in either the grain or livestock industry is allowed to enroll in one of the courses to learn more about that industry. It is anticipated that the majors should cover economic concepts at a more rigorous level than is presented in service courses.

Conclusions

Program review has resulted in a new curriculum and substantial revision of courses. Dropping and revising traditional courses is not without faculty apprehension. Proper administrative procedures that demonstrate concern for the personal welfare of individual faculty and maintaining linkages between the "old" and the "new" can provide the atmosphere necessary to obtain such changes. Generally, the new courses are receiving better response from faculty and students than the courses they replaced.

One reason for the improved response may be that traditional textbooks first written before most undergraduates were born can no longer be used. Even though the texts have been revised, there are few disciplines that have relied on the same basic texts for so long. The reorganization forces instructors to develop newer materials and to evaluate the relevance of each section. Members of the review committee agreed that new textbooks in agricultural economics are badly needed. It is suggested that the American Agricultural Economics Association consider how it might stimulate writing of appropriate new textbooks in agricultural economics.

References

[1] Carnegie Commission on Higher Education, *The More Effective Use of Resources: An Imperative for Higher Education*, New York, McGraw-Hill Book Company, Inc., 1972.

[2] Castle, Emery, "The University in Contemporary Society," *Am. J. Agr. Econ.* 53:551–656, Nov. 1971.

[3] Danskin, David G., James M. Foster, and Carroll E. Kennedy, Jr., *The Attitudes and Ambitions of Students at a Land-Grant College of Agriculture and Their Implications for Curriculum Planning and for Teaching*, Kansas Agr. Exp. Sta. Bull. 479, 1965.

[4] Dobson, W. D., and Robert C. Matthes, "University-Agribusiness Cooperation: Current Problems and Prognosis," *J. Agr. Econ.* 53:557–564, Nov. 1971.

[5] Jones, Lonnie L., Curtis F. Lard, and Lester V. Manderscheid, "Present Status of Quantitative Techniques in Undergraduate Agricultural Economics Programs," *Am. J. Agr. Econ.* 54:102–107, Feb. 1972.

[6] McCorkle, C. O., Jr., "The Changing Political Economy of Higher Education and Its Significance for United States Agriculture," *Am. J. Agr. Econ.* 53:718–727, Dec. 1971.

[7] Nicholls, William H., "Higher Education and Agricultural Economics: A Critical Appraisal," *J. Farm Econ.* 42:969, Dec. 1960.

Economic Growth and Agriculture: An Evaluation of the Compensation Principle *

E. C. Pasour, Jr.

The feasibility of a program to insure farmers against losses due to economic growth is explored. Adjustment problems in agriculture are similar to those of other sectors. The feasibility of a general compensation policy to insure farmers against losses due to economic progress is questioned on practical and theoretical grounds.

Economic growth is often accompanied by differences in relative rates of growth between and within various sectors of the economy. The need for relatively slower growth in food and fiber production, together with the rapid increase in agricultural productivity during the past 30 years, have resulted in chronic agricultural adjustment problems. As one consequence, losses have been imposed on numerous individuals in the agricultural sector. Other individuals have received windfall gains. Increase in agricultural productivity is due in part to government actions including research, teaching, and extension activities.

Should persons suffering losses due to economic growth including government activity in agriculture (or any other sector) be compensated by government? That is, would a program be feasible which would transfer enough of the gain by taxation of the gainers and government payments to the losers such that they will not incur losses?

It is the contention of this paper that such a program would not be feasible. Following a brief discussion of several proposals of this kind for compensation in agriculture, a number of arguments are presented to show why a general policy of compensation to insure against losses associated with economic progress is not appropriate.

Economic growth (or progress) in this paper is taken to mean an increase in real per capita income. There are two welfare aspects of any change in the level of real income. These are efficiency and equity. Efficiency pertains to the amount of net social product while equity relates to the distribution of the product. A particular policy may conceivably involve an increase in output (efficiency) without affecting income distribution. Such a policy represents an unambiguous increase in welfare.[1] Other policies, e.g., "tax reform," may affect income distribution without affecting the level of social product. Most policies affect the distribution of income as well as the level of income. The desirability of any change which affects the distribution of income (whether total product is increased, decreased, or constant) from a welfare standpoint, can only be assessed through the collective choice process.

Some Arguments for Compensation

Some agricultural economists have long argued for a general compensation policy to ease the impact of agricultural adjustments. Heady, for example, points out that government development policies in agriculture (research, credit, education, etc.) lead to increases in agricultural output, which benefit consumers through lower food prices, but lead to reduced farm receipts due to the inelastic demand for farm products. He thus favors "compensation policies to provide farmers with some payoff for this contribution to the national welfare" [8, p. 66]. Heady, however, does not discuss the problem of compensation in general, and it is not clear whether he favors a full or partial compensation policy for individuals in all sectors of the economy adversely affected by government action and/or economic growth.[2]

T. W. Schultz proposes a general compensation policy having the objective "to ensure individuals they will not suffer losses caused by economic progress" [16, p. 557]. He challenges

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[1] The Pareto welfare criterion does not imply that income distribution is unchanged when welfare increases; instead it holds that at least one person is made better off without anyone being made worse off.

[2] Full compensation is necessary to insure against loss. Payment of partial compensation based on individual losses is subject to the same measurement problems as full compensation, however, since full compensation must be known before partial compensation can be determined.

the view that both gains and losses are necessary to induce adjustments by labor and other resources. Instead, Schultz contends that the incentives in a market economy can be preserved by permitting and giving free rein to windfall gains while compensating for producer losses due to economic progress [16, p. 559].[3] He assumes that the losses are much smaller than the gains, and, hence, that the net gains from economic progress are large enough to provide an effective system of incentives. Heady, on the other hand, in comparing the gains to consumers with the losses to food producers associated with government development policies, holds that "we cannot be certain that the sum outcome is positive" [8, p. 42]. Heady's proposal is to adopt a set of compensation policies to insure that the "sum outcome is positive."

Schmitz and Seckler propose that a fraction of the economies generated by technological innovations be allocated out of general taxes to increase the mobility of displaced workers. "Interventions of this sort would allow social costs and benefits to fall more or less randomly on the population as a whole and thus, in a sense, cancel each other. If this were to occur, 'everyone' would be better off with technological change" [15, p. 576]. The extent to which Schmitz and Seckler favor compensation to insure against loss is not clear. However, the quote suggests that from the standpoint of social welfare, all technological change should meet the "Pareto better" welfare criterion.

Losses Due to Government and Current Compensation Policy

Economic growth is closely linked with a host of government activities, and it is frequently difficult to separate the combined effect of government policies affecting agriculture (or other sectors) from other factors affecting economic growth. However, there are many cases where one can identify the losses or gains associated with particular government policies, and the legal system currently provides for compensation under some conditions. Consider now the conditions under which such losses are compensable under current law.

Losses and gains due to government action

There are numerous examples of cases in which direct government action either serves to benefit or harm particular individuals. For example, the institution of a price support program, in which price is supported by restricting output through an allotment scheme, serves to give a windfall gain to producers receiving the initial allotments (and losses to consumers via higher product prices). Similarly, the abolishment of a program of this type causes the current holders of production rights to have a windfall loss. At the local level, zoning land as agricultural may decrease the market value of land.

Compensation under the fifth amendment

The examples just cited pertain to a commonly found class of cases where direct government action imposes windfall losses or gains for which compensation is normally neither paid nor received. What, then, determines whether losses to individuals as a result of acts by government are compensable? The Fifth Amendment to the U. S. Constitution states, "nor shall private property be taken for public use without just compensation." If property is "taken," it is compensable.[4] Land for roads, power lines, etc., are common examples in which land is legally "taken" and, hence, compensable. However, there is no clearcut distinction between losses of property due to legal "takings" under the power of eminent domain and losses in value due to the lawful exercise of "policy power." For example, economic losses incurred by private citizens due to government actions in zoning, nuisance abatement, and business regulation are usually considered to be "a mere incident of the lawful exercise of the 'police power' and thus not compensable" [13, p. 36]. Consequently, losses incurred for a wide range of acts of government are not compensable under present law.

A property right is not an unrestricted right.

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[3] A simple concept of equity would suggest that if individuals are insured by society against losses, then society should be reimbursed for windfall gains associated with acts of government. Such a policy is subject to similar practical and theoretical difficulties as a policy to insure against loss.

[4] It is difficult to define precisely "property" and "taken" in a legal sense. Under the dominant theory of "takings" law, "the criterion for recognizing a particular economic injury which follows from government action as a taking is the extent of economic loss" [14, p. 151]. However, in the case of banning lotteries or the manufacture of liquor, total losses are left uncompensated by redefining these interests as nonproperty.

"Property rights do not refer to the relations between men and things but, rather, *to the sanctioned behavioral relations among men and arise from the existence of things and pertain to their use*" [7, p. 1139].

Imposition of restrictive measures on ownership rights affects the owner's expectations about the potential uses and, hence, the value of the asset involved. However, the theory of property rights is not now complete in the sense that there is no clear theoretical basis for determining the conditions under which attenuation of (or restriction on) private property rights should represent a legal "taking." It may well be that the theory of property rights cannot be complete without a complete theory of the state [7, p. 1140]. The fact that the theory of property rights is not complete serves to increase the risks associated with ownership. Consequently, the risk of potential attenuation of property rights by acts of government is an important determinant in resource pricing and allocation.

In many common cases of windfall gains and losses which can be readily linked to government activity (location of roads, zoning of farmland, etc.), there is no special governmental policy to appropriate gains or to compensate for losses. However, the general system of taxation through the handling of capital gains and losses serves to lessen the impact of realized gains and losses.[5]

There is also a class of cases involving changes in property rights which fit neither of the above categories, *viz.*, "takings" under the law of eminent domain or losses due to the lawful exercise of "police power." For example, in the legislation following the Kennedy round of tariff negotiations, compensation was provided for persons injured by increased imports.[6] Compensation has also been provided in the case where animals have been destroyed to control disease. Compensation was legally denied cedar tree owners in Virginia whose trees were destroyed to protect apple production (this case is discussed later in more detail). What determines when losses imposed on individuals by particular actions of government will (or can) be compensated in situations not covered by the Fifth Amendment? The answer to this question involves a number of factors relating to the feasibility of compensation.

Feasibility of Compensation

A policy of compensation to insure against losses would confront problems associated with measurement, the collective choice process, and moral hazard.

Measurement problems

Measurement problems constitute the first reason why compensation to insure against losses associated with economic progress is often not feasible. Losses associated with economic growth often cannot be measured. How, for example, would one separate losses (or decreases in price) associated with economic growth from other losses (or decreases in price)? Similarly, how would one determine the extent of the loss suffered by any one individual? The administrative problems in determining if a particular loss occurred due to economic progress and then measuring it would be enormous. Hence, measurement problems alone are sufficiently formidable to limit the feasibility of any program to insure against such losses.[7] There are other basic problems, however, which limit the feasibility of any program of this kind.

Public choice

A second reason that a general system of compensation to offset the direct and indirect losses arising from government activity is not feasible is that it would be inconsistent with the role of government of enhancing various self-interests at the expense of other people or groups of people. In virtually every action taken by government, some people gain and some people lose. Specific groups of citizens use the power of the state to enhance their own economic interests relative to those of other groups.[8] Government, in performing its inherent function, must be more responsive to the desires of some individuals and parties than to others in virtually all choices or decisions made. Examples are abundant. Agricultural subsidies, use value property taxation for farmers, a ban on the use of DDT, and the zoning of farmland are examples of choices made by government which are the result of or influenced by specific groups using government for the advancement of their own interests. It is apparent in these and numerous other examples that there is no "common cause." That is, there are competing interests, and any choice made by the people through governmental action will almost inevitably force or coerce certain people to change their behavior in some way.

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[5] In fact, the tax system itself serves as a vehicle through which government appropriates wealth and redistributes income. The taxing power of the state permits private property to be taken for public purposes. Compensation, in the case of property taxes and income taxes, is not paid to the taxpayer except to the extent that the amount of taxes paid by an individual is coincident with the benefits received from governments. A policy to insure against loss would effectively mean that the tax burden for any individual should be based solely on the criterion of benefits received instead of the now dominant criterion, ability to pay.

[6] This is a case in which *potential* losses are compensable.

[7] A recent study of the feasibility of an insurance program to protect farmers and ranchers against economic losses caused by restrictions in the use of crop pesticides and predator poisons reached a similar conclusion, "isolating such losses from other losses in crop and livestock production is impossible in most instances" [9, p. iv].

[8] This, of course, does not preclude the possibility that certain groups might be sufficiently influential to obtain compensation for actions taken which are deleterious to their interests.

A third (and closely related) reason why a general policy of compensation is not feasible hinges on the fact that governmental choice is also required in determining and adjudicating property rights between individuals in the private sector where externalities are involved. This point is convincingly made by Samuels in citing a 40-year-old court case in Virginia [12]. The case involved the property rights of producers of red cedar trees versus the rights of apple producers whose apples were being damaged by the cedar rust. The cedar rust is a fungus harmless to cedar trees but which spends one phase attacking apple leaves and fruit. The Virginia legislature "passed a statute which empowered the state entomologist to investigate and, if necessary, condemn and destroy, without compensation, certain red cedar trees within a two-mile radius of an apple orchard" [12, p. 436].[9]

The government, prior to the legislative ruling, was effectively working to the advantage of the cedar tree producers. By passing the new law, the situation was reversed and government effectively supported the apple producers. Government, in this example, was forced to choose between the interests of the two groups of producers.[10] Such choices are inevitable. Government in general is an instrument for the accommodation of conflicting interests.

A slightly different way of viewing the second and third reasons why compensation to insure against losses is not feasible follows from the fact that externalities are inherent in the collective decision-making framework [3]. In the collective choice process of a democracy, there is virtually always a minority who disagrees with any collective decision reached or action taken even though the decision made represents the majority will. Thus, a member of the minority must accede to actions favored by the majority which he cannot prevent and for which he does not receive compensation or damages. Hence, the collective decision-making process inevitably imposes external costs on particular individuals. If full compensation were paid in such cases, it would be tantamount to the adoption of the unanimity decision rule which is likely to be of limited practical usefulness.[11]

Risk and moral hazard

Under current law, there is little basis for the contention sometimes made that an individual has a right to expect that legislation affecting him will not change appreciably. The law has often changed in ways that have worked to the disadvantage of individual property owners. For example, legislatures have passed laws prohibiting the continuance of businesses (without compensation) which were legal when established. Examples are lotteries and the manufacture of liquor [13, p. 52]. Agricultural examples, such as nuisance ordinances and water pollution legislation which restrict or prohibit the activities of hog farms and feed lots, are also becoming quite common.

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[9] There is no consensus among economists as to the correct approach to externality problems of the cedar-apple variety. Coase holds that such problems have a bilateral nature and that the proper approach is to focus on the efficient *use* of the scarce resource [5]. This approach which does not attempt to identify the perpetrator or the victim generally calls for all parties using the scarce resource to be taxed so they will economize on the use of the scarce resource. Baumol, on the other hand, purports to show that victims of externalities should *not* be taxed or compensated [2].

[10] This does not mean, of course, that government may never compensate the losers in such cases. In cases where losers are compensated, the government has effectively chosen between two groups—taxpayers in general and the group being compensated.

Coase has shown that in small number settings, the same result would be expected to emerge by voluntary agreements regardless of how the law assigns property rights [5]. Well defined property rights are important in reaching voluntary agreements which can serve to internalize the interdependence between parties [17]. Buchanan contends that there should generally be an explicit prejudice in favor of previously existing property rights since "only such a prejudice offers incentives for the emergence of voluntarily negotiated settlements among the parties themselves" [4, p. 452].

[11] Since an individual would be paid to compensate him for the cost imposed upon him by virtue of being in the minority, he would have an incentive not to reveal his true preference and to exploit others for his own uniquely differential benefit.

There is a distinction between insurable and noninsurable risks which is important in assessing the feasibility of a general compensation policy. Some individual risks can be pooled so that the aggregate risk is less than the combined risks to the individuals. In such cases, private insurance companies can provide a useful function. In other cases, however, such as that of society's changing demands for skills, the risks are not a poolable sort "since the individual events which combine to form the aggregates are not independent of one another" [10, p. 5187]. This is the "moral hazard" problem and the fourth reason why a general policy to insure against losses is not feasible.

Moral hazard refers to the fact that an insurance policy might have a deterrent effect on self-protection (i.e., acts which reduce the probability of a loss) which increases the probability of a hazardous event actually occurring. Arrow holds that "moral hazard" is an important factor limiting risk-shifting and results in incomplete coverage of risky activities through the market [1, p. 142]. Moral hazard constitutes a cost, and it is likely to be economical to leave some risks uninsured through the market (or by government) because the moral hazard cost is too large.[12]

What is the significance of moral hazard to the compensation issue? Schultz (as indicated above) contends that gains associated with economic growth are much larger than losses within the present institutional framework [16]. A compensation rule, however, would represent a pronounced institutional change. A new institutional framework which includes a compensation principle to insure against losses associated with economic growth is likely to increase "bad" or risky investments since expected losses would always be nonpositive. Thus, the expected result of the compensation rule (when contrasted with the present institutional framework) would be to increase the ratio of losses to gains. Further taxation of gains to compensate losses might be expected to reduce economic growth.

In slightly different terms, if individuals were completely insulated from risks associated with economic progress, i.e., if there were total risk shifting, the probability of incurring loss would increase due to moral hazard.[13] Any attempt to insulate an individual against loss due to economic progress is likely to reduce the rate of economic progress and reduce the "surplus" available for compensation.[14]

Conclusion

Attempts to insure farmers against losses arising from economic progress suggest that adjustment problems in the agricultural sector are, in some sense, unique. There appears to be no fundamental difference, however, in the effects of such changes on agriculture and those on other sectors of the economy. Changes in demand and supply are ubiquitous in a changing economy. The number of individuals involved in a specific case of technological displacement is important from the standpoint of the transactions costs (relative to the benefits) in devising policies to facilitate the necessary labor adjustments. From an equity standpoint, however, the number of individuals affected has little relevance. The small (or large) numbers of individuals who are disadvantaged by any of the innumerable changes of a dynamic economy would appear to have an equal claim to compensation.

A policy of general compensation to insure farmers or other individuals against losses, due to economic progress (or government action), does not appear sound either practically or from a theoretical standpoint. In exercising choice between different alternatives, the government inevitably serves to promote the interests of particular individuals or groups at the expense of other individuals or groups. Consequently, it is not generally possible for a government to enhance the interests of all its constituents simultaneously. A system of general compensation to offset the direct and indirect losses associated with acts of government affecting economic progress would be inconsistent with this role of government. Furthermore, measurement problems and moral hazard would limit the feasibility of a general compensation policy of this kind.

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[12] Ehrlich and Becker show that in cases where the price of market insurance is independent of expenditures on self-protection, moral hazard would exist and hold that "this is the major reason why certain kinds of hazards, like failure in business, are not considered insurable by the market" [6, p. 643]. The example cited is closely analogous to that of insuring individuals against losses arising from economic growth.

[13] Features of formal insurance which reduce the moral hazard factor include deductibles and coinsurance (which requires the individual to pay some fraction of each dollar of cost) [11, p. 535]. Unemployment compensation at some fraction of one's regular wage instead of the full amount is consistent with the contention that the moral hazard factor limits the risk-shifting of insurance programs against unemployment.

[14] The problem is closely analogous to that of the use of subsidies to correct for an externality in the case of pollution by, say, a waste treatment plant. The correct subsidy should be based on an unobservable quantity, *viz.*, how much pollution is reduced below what it would have been in the absence of the subsidy. If one subsidizes actual waste treatment, the person receiving the subsidy may have an incentive to adopt techniques which increase pollution in order to qualify for larger payments due to treating it.

This problem was found to be important in examining the feasibility of insuring losses to farmers and ranchers caused by restricted use of crop pesticides and predator poisons. "If insurance coverage is excessively high, the insured person may tend (by intention or neglect) to contribute to and profit by, a loss if he has any control over it" [9, p. 3].

References

[1] Arrow, K. J., *Essays in the Theory of Risk Bearing*, Chicago, Markham Publishing Company, 1971.

[2] Baumol, W. J., "On Taxation and the Control of Externalities," *Am. Econ. Rev.* 62:307–322, June 1972.

[3] Buchanan, J. M., and G. Tullock, *The Calculus of Consent*, Ann Arbor, University of Michigan Press, 1962.

[4] ———, "Politics, Property, and the Law: An Alternative Interpretation of Miller *et al.* v. Schoene," *J. Law and Econ.* 15:439–452, Oct. 1972.

[5] Coase, Ronald, "The Problem of Social Costs," *J. Law and Econ.* 3:1–44, Oct. 1960.

[6] Ehrlich, Isaac, and G. S. Becker, "Market Insurance, Self-Insurance, and Self-Protection," *J. Pol. Econ.* 80: 623–648, July–Aug. 1972.

[7] Furubotn, E. G., and S. Pejovich, "Property Rights and Economic Theory: A Survey of Recent Literature," *J. Econ. Lit.* 10:1137–1162, Dec. 1972.

[8] Heady, Earl O., *A Primer on Food, Agriculture and Public Policy*, New York, Random House, 1967.

[9] Jones, L. A., *Insuring Crop and Livestock Losses Caused by Restricted Pesticide Use: An Appraisal*, USDA ERS-512, Jan. 1973.

[10] Nerlove, Marc, "On Tuition and the Costs of Higher Education: Prolegomena to a Conceptual Framework," *J. Pol. Econ.* 80:S178–S218, May–June 1972.

[11] Pauly, Mark V., "The Economics of Moral Hazard: Comment," *Am. Econ. Rev.* 58:531–537, June 1968.

[12] Samuels, Warren J., "Interrelations Between Legal and Economic Processes," *J. Law and Econ.* 14:435–450, Oct. 1971.

[13] Sax, Joseph L., "Takings and the Police Power," *Yale Law J.* 74:36–76, Nov. 1964.

[14] ———, "Takings, Private Property and Public Rights," *Yale Law J.* 81:149–186, Dec. 1971.

[15] Schmitz, A., and D. Seckler, "Mechanized Agriculture and Social Welfare: The Case of the Tomato Harvester," *Am. J. Agr. Econ.* 52:569–577, Nov. 1970.

[16] Schultz, T. W., "A Policy to Redistribute Losses from Economic Progress," *J. Farm Econ.* 43:554–565, Aug. 1961.

[17] Seagraves, J. A., "On Appraising Environmental Institutions," *Am. J. Agr. Econ.*, this issue.

On Appraising Environmental Institutions*

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Changing relative prices and conditions of profitability lie behind many demands for new institutions. The emerging nature of environmental disequilibria suggests that allocative effects of alternative institutions can be studied before the difficult question of income distribution. "Externalities" are viewed as joint products, one of which is not priced.

A POSITIVE economics of environmental institutions is a necessary prerequisite to the development of worthwhile normative prescriptions. This paper stresses the need for the normative engineers of social change both to understand this positive economics and to evaluate solutions that have been tried in other regions.

Engines of Institutional Change

The induced innovations hypothesis emphasizes that changes in factor prices influence technological change so as to conserve the newly high-priced factors. Hayami and Ruttan [9] make institutions such as Agricultural Experiment Stations and farm machinery companies vital links in their explanation of induced technological change. Ruttan [13] has suggested that the induced innovations idea be applied to institutions as well. Schultz [17] has given an economic framework for explaining changes in institutions. He concentrates on

> Institutions that Render Services to the Economy . . . A partial list includes . . . (1) those that reduce transaction costs (for example, money, future markets), (2) those that influence the allocation of risk among the owners of the factors of production (contracts, share tenancy, cooperatives, corporations, insurance, public social security programs), (3) those that provide the linkage between functional and personal income streams (property, including inheritance laws, seniority and other rights of labor), and (4) those that establish the framework for the production and distribution of public goods or services (highways, airports, schools, agricultural experiment stations).
> . . . For each of these services there is a demand. It is, therefore, within the province of economic theory to approach the determination of the economic value of each of these services by subjecting them to a supply-and-demand analysis . . . an economy arrives at an equilibrium with respect to each of these . . . economic services of institutions when the rates of return represented by these and other services reach equality. [17, pp. 1114, 1117]

Davis and North [7] offer a theory of "arrangemental innovations" with emphasis placed on new opportunities for profit leading to changes in institutions. New knowledge, prices, or rules of the game show up as economies of scale, externalities, market failures, or political pressures which suggest benefits that can only be captured by some change in the arrangemental structure. Emphasis is also given to reduced costs of bringing about changes or operating the new institutions as explanatory variables. Once the ice is broken, or the first organization is established, similar changes become easier.

Schultz and Davis and North seem to be stressing the overall social profitability of new institutions and lead one to expect institutional changes as knowledge and prices change. Samuels [14; also see 15 and 1] stresses the profit motives and power of individual groups in his interpretation of the Supreme Court case, Miller *et al.* vs. Schoene, which upheld the Virginia law protecting the owners of apple orchards from the red-cedar trees of their neighbors. The cedars are the host plant to a fungus which affects the apples. If 10 or more apple growers register a complaint, the State Entomologist may declare the offending cedars a public nuisance and order them removed. New knowledge may have been partly responsible for the timing of this 1914 law, but Samuels describes it as a case of the economic power of the apple

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growers leading to the law and its successful defense through the courts. It is also possible that condemnation seemed like a less costly and simpler institutional procedure than having a group of orchardists buy easements from the owners of the cedar trees.

One generalization that can be drawn from this brief review is that several causal factors can be involved in explaining any one institutional change. Two other thoughts are: (1) that even though legislators are looking for low-cost answers to problems, they are likely to adopt simple regulations and "do something decisive" rather than encourage the use of markets; and (2) by itself, the process of correcting problems can make issues which seemed trivial in years past worth solving today. This second aspect of governmental problem solving resembles competition.

Environmental Institutions

Changes in relative prices, incomes, tastes, and technology are creating demands for new environmental institutions. Increases in real wage rates and the value of time have been most dramatic. These have caused some environmental issues to become noticeable. Wage rates have gone up relative to the cost of water and the value of many by-products. Industry has responded by using more water to flush away more joint products that are now slightly submarginal. While higher wage rates have caused an increase in the supply of wastes, the increased standard of living has helped cause an increase in the demand for recreation and a clean environment. Population increase is another reason, but this appears to be under control. Concern with the environment is not likely to be a passing fad. It has grown from real changes in prices and incomes, and these changes are continuing.

If economists were better able to understand the causes of environmental problems, it would help in the consideration of alternative solutions. Are there any other parts of the world that have already suffered (or enjoyed) the same changes in relative prices or profit conditions at an earlier date? Do the solutions adopted there suggest anything? If a shortage of water is developing, one can look at the solutions tried in the more arid areas. The same applies to developing shortages of the waste-assimilative capacities of the water and air. Most economists can think of places that have had more severe problems and more extreme resource price ratios than those in question. This sounds like the old farm management approach, which simply reported to all farmers what the successful farmers were doing. However, there is a difference. Such observations can be used to enhance theoretical understanding of and to test predictions about institutional changes.

"Externalities" or "Joint Products"

The concept of "externality" is often value-laden, suggesting that there are "bad guys" and "good guys."[1] The concept is vague as well. Sometimes it refers to joint-products, one of which is not priced, and at other times simply means economies of size made possible by expanded consumption. Some authors [4, 6] use the concept of "externality" as an alternative to property rights problems, and others [10] treat these as separate classes of environmental problems requiring different types of policies. "Externalities" almost always implies that something is wrong without necessarily encouraging an explanation of why. The word "externalities" is also associated with simplistic solutions—internalize them, tax them, or prohibit them.

Cheung [4] suggests that it would be fruitful for economists to reorient their thinking toward transactions costs and property rights and to discard the concept of externality. He would ask economists to quit attributing to Coase [5] the position that property rights are irrelevant, and to recognize that transaction costs lie at the heart of the *problem* of social costs. Coase emphasizes that similar optimum levels of pollution can come about regardless of whether an offending party has the right to pollute or the offended has property rights that protect him from damages caused by others. Solutions will be similar (aside from aggregate price effects) as long as transaction costs are low. Calabresi [3] carries the story one step further and shows that there are no resource allocation problems of any kind, even with monopolies, as long as transaction costs are zero. If consumers could easily get together, they could bribe a monopolist to produce the competitive amount. It would not matter whether the monopolist was restricting supply, exploiting a legitimate patent, or using up all the oxygen in a river; as long as transaction costs are low for those who are hurt, they should be able to get together and buy themselves into a Pareto optimal solution.

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[1] One reviewer kindly pointed out that the word "inefficiency" is also value laden. This is true, and the two are almost synonymous. However, it is possible that "inefficiency" and "Pareto relevant inefficiency" are less prescriptive.

In personal correspondence regarding stream charges versus transferable permits, Robert Dorfman made the point that the asymmetry between the polluters and the pollution resisters can best be viewed as a special case of concentrated interests dominating diffuse interests in the political sphere. Diffuse interests are at a disadvantage because of high communication costs and problems with free riders. Hence, any policy based on an assumption of low transactions costs among those with diffuse interests is suspect. Crocker [6] made the point that the assignment of property rights can have a large effect on the informational, contracting and policing, or ICP, costs. The optimum solution to a problem of joint products, one of which is not priced, may well involve a redistribution of income and few subsequent transactions.

Cheung [4] explains the common property resource (fishing) problem with a general theory as to when it becomes profitable to establish a right to exclude others or a monopoly. New institutional forms come about when the benefits of establishing them increase or their marginal costs decline. Preferred forms may include more separate bundles of rights and obligations, better enforcement, and more information being conveyed by markets. Costs include all the ICP costs of Crocker. Benefit cost analyses may help explain why contracts or exclusive rights do not yet exist for certain actions, or why an older institutional form persists.

Most "externalities" can be defined as joint-products, one of which is not priced. The "Pareto-relevant externalities" of Buchanan and Stubblebine [2] are a special class of situations in which someone can be made better off without hurting others presumably after paying any additional transactions costs of the new institutions that may be involved. The question is whether "externalities" are meaningfully different from any other Pareto relevant disequilibria. Cheung says no.

Separating Allocative and Distributive Effects

Economists can also discount the idea that it is necessary to know who counts, or "who is imposing upon whom," or who has the property rights before one can usefully make efficient analyses of these troublesome joint-products.[3] When the costliness of a common property right is just emerging, or when court decisions to assign responsibilities are costly, the institutional economist is mainly concerned with whether or not the efficiency gains can support a newly defined right. Do the benefits of defining rights exceed the ICP costs? What are the alternative institutions? It is true that the task of the institutional economist will be easier if he already knows who counts and that this knowledge may keep him from getting himself in trouble in those cases where property rights are valuable. But it will often be useful to consider separately the questions of resource allocation or efficient institutions on the one hand and redistributions of wealth on the other. If there is no way to increase the size of the pie by creating a new environmental institution, then the redistributional effects would have to be very dramatic to merit study. It also makes sense to study allocative effects first. One should not expect environmental programs to be effective ways to help the poor.

Two Local Examples

Elliott [8] recently completed a study of the industrial demand for waste treatment in cities that are levying surcharges on the pounds of industrial waste treated. These are special charges in addition to the normal sewer charge based on volume. Higher charges had the expected negative effects on water use and water-carried wastes. The new institution in this case is a "slightly more sophisticated way of charging for wastes." What caused it? High costs of waste treatment and extra heavy industrial waste loads. Elliott's thesis helps explain the latter, too. Higher real wage rates were positively associated with higher uses of water to flow away industrial wastes both cross-sectionally and over time, as expected. Another observation is that the cities with the highest waste treatment costs have been more inclined to charge industry for the pounds of waste treated (use the more sophisticated institutional form) than have cities with lower costs. That is, those cities that had relatively high benefits from establishing the new billing procedure were the first to adopt it.

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[3] The primacy of the question of "whose ox is being gored" was claimed by Schmid [16, see paragraph 2 of his conclusions] and also by Headley [10, see paragraph 2 of his section on Property Rights and the Environment].

Does the successful experience of most cities that have tried surcharges have any normative implications for institutional changes to regulate the quality of rivers? Senator Proxmire [12] has used the experience of surcharges to support the idea of charging industries by the pound for wastes that they discharge to streams. Elsewhere [18] the author has argued that stream charges are a simple alternative, but not likely to be optimal. The main points are that governmentally levied stream charges would not necessarily encourage a market test regarding the optimum quality of the river; would most likely be applied in too simple a way or with too few variations in the charges to accommodate geographic and temporal differences in the waste assimilative capacities of streams; and would imply a redistribution of property rights which is larger than necessary and, hence, might delay the passage of the legislation. Mar's [11] alternative of transferable discharge rights defined in terms of the obligations that major dischargers have with respect to water quality at some point downstream from their outfalls deserves more consideration. His proposal would allow a downstream city to bargain with an upstream city so that the former might pay the latter to adopt higher standards than those dictated by their discharge rights.

This second example is a classic common property resource problem. The waste assimilation capacity of streams is gradually becoming more valuable. But the value of this previously undefined resource varies a great deal from time-to-time and place-to-place. The property rights literature would lead one to expect a variety of solutions. One problem with an "externalities" approach is that it suggests simple charges or regulations and a sudden rearrangement of property rights against those who had been freely using the stream to assimilate wastes. This may not be the most expedient route politically, and if successful politically, it may overshoot the mark economically. Another problem with the charges approach is that it does not encourage one to ask whether administrative costs might not exceed the benefits in terms of resource allocation.

Conclusions

The normative environmental economist needs to cultivate his positive economics of institutional change. Understanding the demands for change and the changes that have been made elsewhere are useful steps along the way and suggest a comparison of many alternative solutions. The property rights approach to environmental problems appears to be more objective and to suggest more alternatives than the "externalities" route. But one should avoid simple assumptions that transaction costs are low or that diffuse interests can bargain as effectively as concentrated interests. This property rights approach does not recommend adoption of new institutions unless the allocative benefits exceed the transaction and policing costs. It is logical for the institutional economist to calculate net allocative gains before he worries about any redistributions of incomes that may be involved or about short-run compensation schemes and political strategy.

References

[1] BUCHANAN, JAMES M., "Politics, Property, and the Law: An Alternate Interpretation of Miller *et al.* v. Schoene," *J. Law and Econ.* 15:439–452, Oct. 1972.

[2] ———, AND WILLIAM CRAIG STUBBLEBINE, "Externality," *Economica* 29:371–384, Oct. 1962.

[3] CALABRESI, GUIDO, "Transactions Costs, Resource Allocation and Liability Rules—A Comment," *J. Law and Econ.* 11:67–74, April 1968.

[4] CHEUNG, STEPHEN N. S., "A Structure of a Contract and the Theory of a Non-Exclusive Resource," *J. Law and Econ.* 13:49–70, April 1970.

[5] COASE, RONALD, "The Problem of Social Cost," *J. Law and Econ.* 3:1–44, Oct. 1960.

[6] CROCKER, THOMAS D., "Externalities, Property Rights and Transactions Costs: An Empirical Study," *J. Law and Econ.* 14:451–464, Oct. 1971.

[7] DAVIS, LANCE E., AND DOUGLASS C. NORTH, *Institutional Change and American Economic Growth*, London, Cambridge University Press, 1971.

[8] ELLIOTT, RALPH D., "The Industrial Demand for Water and Waste Treatment in Selected U. S. Cities Which are Levying Surcharges," unpublished Ph.D. thesis, North Carolina State University, 1972.

[9] HAYAMI, YUJIRO, AND VERNON W. RUTTAN, *Agricultural Development: An International Perspective*, Baltimore, The Johns Hopkins Press, 1971.

[10] HEADLEY, J. CHARLES, "Agricultural Productivity, Technology and Environmental Quality," *Am. J. Agr. Econ.* 54:749–756, Dec. 1972.

[11] MAR, B. W., "A System of Discharge Rights for the Management of Water Quality," *Water Resources Res.* 7:1079–1086, Oct. 1971.

[12] PROXMIRE, WILLIAM, Remarks in support of his proposed amendment to S 2770, *Congressional Record*, 92nd Cong., Vol. 117, No. 164, S 17426.

[13] RUTTAN, VERNON W., "Technological Change and the Environment," *Am. J. Agr. Econ.* 53:707–717, Dec. 1971.

[14] SAMUELS, WARREN J., "Interrelations Between Legal and Economic Processes," *J. Law and Econ.* 14:435–450, Oct. 1971.

[15] ———, "In Defense of a Positive Approach to Government as an Economic Variable," *J. Law and Econ.* 15:453–459, Oct. 1972.

[16] SCHMID, A. ALLAN, "Analytical Institutional Economics: Challenging Problems in the Economics of Resources for a New Environment," *Am. J. Agr. Econ.* 54:893–900, Dec. 1972.

[17] SCHULTZ, T. W., "Institutions and the Rising Economic Value of Man," *Am. J. Agr. Econ.* 50:1113–1122, Dec. 1968.

[18] SEAGRAVES, J. A., "Surcharges and Stream Charges as Economic Incentives," paper presented at the National Symposium on Costs of Water Pollution Control, WRRI, North Carolina State University, Raleigh, North Carolina, April 6–7, 1972.

Cost-Benefit Analysis of Irrigation Projects in Northeastern Brazil*

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Cost-benefit analysis using empirical estimation of labor's shadow price and linear programming for crop selection is applied to major proposed irrigation projects for Brazil's Northeast. Over half the project area is approved. However, these capital intensive projects should rank below investments with similar rates of return but larger employment effects.

This study conducts cost-benefit analysis of 24 major irrigation projects presently under consideration for the arid interior of Northeastern Brazil. These are among 56 projects with a total area of 195,000 hectares, tentatively found favorable by the Brazilian Ministry of Interior, on a 10 percent discount rate basis.[1] The potential investors in the projects are the Brazilian government and international lending agencies.

The projects tend to be large government schemes rather than plans for small scale private irrigation. Although many of the projects would use reservoirs constructed in past anti-drought programs, they would be costly due to long conduction canals, drainage requirements, or high pumping from rivers. The average investment cost is $2,800 per hectare ($1,700 excluding buildings, farm machinery, and workers' houses), very high by international standards.[2] Correspondingly, the projects are capital intensive. They would employ 0.59 workers per irrigated hectare, giving a capital/labor ratio of $4,800, more than seven times the average capital/labor ratio in Brazilian agriculture.[3]

Their high capital intensity means the projects would contribute very little to labor absorption. Even if the full area of 195,000 hectares were implemented, only 115,000 permanent direct jobs would be created [3, p. 8]. This level represents approximately 2 percent of the current rural Northeastern labor force and would not be fully reached until complete project installation in 1980. Despite the small impact on Northeastern employment, the projects would require the very sizable investment total of $548 million.[4]

Methodology and Data

Methods used in this study resemble those employed in the original *PPI* study, with two important exceptions: (1) labor costs are evaluated at an empirically estimated shadow price rather than at the legal minimum wage; and (2) optimal cropping schemes based on linear programming are used in this study. The crop schemes in the original consultants' study were devised through a process linking production of high value crops on each project to neighboring markets and tending to place sufficient high value crops on each project to pay for its investment costs.

In the underemployment context of Northeastern Brazil, it is important to use an accounting price of labor in project evaluation. The shadow price[5] of labor used here is the

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* The research for this study was conducted while the author was a Ford Foundation Visiting Professor in the Brazilian Planning Ministry (IPEA), 1970–71. The author is indebted to Gervasio Castro de Resende for vital assistance in data collection, and to members of the Tahal consulting firm for their cooperation in supplying data and expert agronomic and engineering advice. The views here do not necessarily represent positions of the Brazilian Planning Ministry.

[1] The analysis was conducted by the consulting firms Tahal (Israeli) and Sondotecnica (Brazilian). Summary results of the analysis are reported in [3], referred to below as *PPI*. Note that the 195,000 hectare area represents more than twice the area presently under irrigation in the region.

[2] Colin Clark cites figures in the vicinity of $500 per hectare as the investment cost of irrigation works for projects in Europe, Iraq, and Morocco [5, p. 62].

[3] I estimate this as $640, based on the 1960 census, farm sample survey data, and national accounts. (Note, however, that 9 percent of the irrigation investment cost would be "colonization" costs—workers' housing, school buildings, etc.)

[4] This amount represents on the order of one-half of one year's total investment in the Northeast (estimated as 4.9 billion cruzeiros, or $US 1.2 billion, in 1969), although the irrigation investments would be phased over a decade. See [4, p. 22].

[5] The shadow price does not include an increment above marginal value product to account for supposed savings losses of labor intensive methods, as recommended for the industrial sector by Little and Mirrlees [7]. Such an adjustment for savings effects is inappropriate here because in family farm agriculture the worker is at the same time

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weighted average of estimated marginal value products within farm size and product sector subgroups, with weights proportional to the percentage of labor force in each subgroup. This approach gives the "expected" opportunity cost of labor if the probability of drawing a worker from a given subsector is proportional to the subsector's share in the labor force.

The empirical estimate is based on production functions for Northeastern agricultural sectors previously estimated by the author.[6] The result for 1969 is a shadow price of 375 new cruzeiros per man-year (U.S. $89 per year), or only 43 percent of the minimum wage. For future years, 3 percent annual growth in the shadow price is assumed.[7]

The second important methodological step is to select the crop mix for the irrigation projects, using a linear programming optimization incorporating demand limitations. High value per hectare crops are required for the projects to pay their heavy investment costs, and yet these crops are "luxury" goods with limited markets. Exclusive utilization of these crops (e.g., tomatoes, grapes, melons, pineapples) could result in absurdly large production levels relative to the national market. Therefore, a realistic set of demand constraints must be imposed on the individual goods. To obtain a reasonable set of constraints, the author has merely set 15 percent of estimated 1980 Brazilian production of each crop as the maximum which could be forthcoming from these irrigation projects without exceeding market demand.[8] Exportation is not considered.[9]

The optimal crop selection program is:

$$(1) \qquad \text{Max } Z = \sum_i \sum_j \pi_{ij} X_{ij}$$

subject to

$$(2) \qquad \sum_j X_{ij} \leq 1.75\, A_i \qquad \text{(9 equations)}$$

$$(3) \qquad \sum_i X_{ij} q_{ij} \leq \hat{Q}_j \qquad \text{(21 equations)}$$

$$(4) \qquad X_{ij} \leq \gamma_j (1.75 A_i - \sum_k X_{ik}) \qquad \text{(89 equations).}$$

In this model the basic activity level X_{ij} is one semi-annual hectare of soil type i planted to crop j.[10] The half-year is the time unit of production activity because most of the crops considered may be double-cropped in one year. The parameters π_{ij} indicate the profitability per semi-annual hectare of crop ij defined as:

$$(5) \qquad \pi_{ij} = q_{ij} P_j - C_j^*$$

where q_{ij} = yield per hectare of crop j on soil i, and P_j is price to the farmer per ton of crop j.[11] C_j^* is current cost of per-hectare inputs of labor, machinery services, animal power, and intermediate inputs, with labor evaluated at the initial shadow price.[12]

Equation (2) contains the land and crop-intensity constraints: total semi-annual hectares activity on soil i may not exceed 1.75 times physical area available in that soil (A_i).[13] Equation (3) is the demand constraint: total production of good j is the sum over all soil types of semi-annual hectares in crop j times

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entrepreneur, and the conventional savings dichotomy between the two is irrelevant. Furthermore, the Brazilian fiscal system appears sufficiently capable of extracting savings that a consumption-savings adjustment on labor's price should not be used in project analysis.

[6] See [6]. The relevant sectors are: Ceara cotton, cattle; Pernambuco sugar, cotton.

[7] Since marginal product equals average product times elasticity of output with respect to labor, if the elasticity is assumed constant, the marginal product will grow at the same rate as average product—which rose 3 percent annually during the 1960's.

[8] 1980 production is projected with an annual growth rate for all products of 4.5 percent, the trend rate of the 1960's. The demand constraints described here differ from those employed in the *PPI* study, which were based on projections of "excess demand" for products from non-irrigated agriculture. The excess demand was calculated for each product by comparing demand projections (based on income elasticities) with non-irrigated supply projections. A simpler method is chosen here because of the very unreliable nature of such excess demand projections, given their high degree of sensitivity to assumptions about future output growth for individual products.

[9] The virtual non-existence of present exports in most of the "luxury crops" of importance means that marketing networks abroad for these goods cannot be assumed to be available.

[10] Nine soil types are considered: U. S. Bureau of Reclamation classifications *2s*, *2d*, *2st*, *3s*, *3t*, *3d–3dk*, *3sd*, *3st*, and *4d*.

[11] Note that the price used is constant, independent of production level. Imposition of the demand constraint permits the assumption of constant real prices.

[12] For crops requiring a full year for production (including tree crops), the yield q_{ij} is one-half nominal yield, for consistency with the specification of semi-annual hectare production units. Furthermore, for perennial crops, both yield q_{ij} and current cost C_j^* are based on annualized values with present value (under 10 percent discounting) equal to that anticipated over the product life cycle, to account for variable yields (initially zero) and variable costs (including heavy initial investment costs) over the cycle.

[13] Complete double-cropping would raise the crop intensity multiple to 2, for two semi-annual hectares of production per year.

respective yields, and this sum may not exceed the demand constraint $\hat{Q}_j$. Equation (4) is the rotation constraint, requiring that no more than a given fraction γ_j of any area free for rotation may be planted in crop j. Since area in perennial crops is ineligible for rotation, it is excluded [i.e., the last element in equation (4) where subscript k refers to perennial crops].

Once the solution to the above programming problem is obtained, the resulting optimal crop mix is known for any given soil type from the percentage composition of optimal semi-annual hectare activities X_{ij} on that soil (i).

The final cost benefit calculation for each project is:

$$(6)\quad BCR = \frac{PVBN - (PVM + PVR + PVO - PVD)}{PVI}$$

where BCR = benefit/cost ratio; $PVBN$ = present value of production benefits net of current costs; PVM = present value of the stream of project maintenance costs; PVR = present value of reinvestments for equipment with life shorter than the project life (50 years); PVO = present value of land opportunity cost; PVD = present value of salvaged installations and equipment at end of project life; and PVI = present value of the stream of project investments in dams, pump equipment, drainage system channels, farm machinery, buildings, and roads (in most cases spaced over a period of four or five years).[14] Of these elements, only the term $PVBN$ requires further description.

$$(7)\quad PVBN = [1/(1 + r)^n] \sum_i a_i \pi_i^*.$$

In this calculation, the present value of output benefits less current costs is strictly determined from aggregate area of soil type (a_i), "average year of start-up" (n),[15] and a parameter π_i^* showing present value of profitability per physical hectare of soil i for a time span of 50 years beginning in year 1. The discount rate is r.

The parameter π_i^* is calculated as:

$$(8)\quad \pi_i^* = 1.75 \sum_j \lambda_{ij} \cdot \left[\sum_{t=1}^{50} \frac{1.08 P_j q_{ijt} - C_{jt} - AI_{jt}}{(1 + r)^t} \right]$$

where λ_{ij} is the fraction of soil i cultivated in crop j in the optimal crop selection from the programming solution; P_j is the price per ton of crop j; and q_{ijt} is the yield in tons per semi-annual hectare for crop j on soil i in year t of a standardized 50 year life beginning in year 1 (constant overall t for non-perennial crops).[16] C_{jt} is the current cost per semi-annual hectare of crop j in year t; and AI_{jt} is agricultural investment in crop j in year t (applicable only in the beginning of the life cycle of perennial crops). The entire expression is multiplied by 1.75, the cropping density factor.

Once the benefit/cost ratios are calculated, some of the projects are found unfavorable. Therefore parts of the quotas of high value crops remain unused. The next step is to concentrate these unused crops onto the projects approved in the "first round" (replacing some lower value crops), thereby raising their profitability still further. The final step is then to allocate the high value crops still below full quota use onto the rejected projects, in order of ascending "present value of investment and maintenance costs" per project area for each project. The final optimal set of projects is obtained when no more rejected projects can be turned positive—because their investment costs are high and because most of the high value crop quotas are exhausted.[17]

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[14] Note that the costs PVM, PVR, and PVO are deducted from the numerator rather than added into the denominator. Decision making based on the benefit/cost ratio maximizes the numerator relative to the denominator. Since PVM, PVR, and PVO are future costs whereas PVI is initial investment, it is most appropriate to maximize with respect to PVI and to treat PVM, PVR, and PVO by netting them out of the numerator to obtain net future benefits—just as intermediate input costs of future production are netted out in calculating future benefits rather than being included in the denominator of the benefit/cost ratio. Note further that at the present stage of planning the exact incidence of these various costs between the government and farmers is unclear.

[15] For example, if one-fifth of the project area is to be executed in each of the first five years, the average start-up year n is three.

[16] This is multiplied by 1.08, the net effect of a 10 percent reduction to capture the delayed attainment of full yields during the learning process for the farmers, and an 18 percent write-up for indirect agricultural taxes. (Social benefits must be evaluated at price *cum* indirect tax—to reflect scarcity value to the consumer—whereas product price to the farmer excludes indirect tax.)

[17] In Table 1 below, all projects with benefit/cost ratios above unity (on the 10 percent, shadow price of labor basis) are among the set successful on the first round, except for Boacica and Rio Grande.

Table 1. Benefit cost ratios: selected irrigation project proposals, Northeastern Brazil

Project	State[a]	Area (hectares)	Investment[b] (Million Cruzeiros of Nov. 1969)	Benefit/Cost Ratios[c] 10 percent M	10 percent S	15 percent M	15 percent S
Aires de Souza	CE	1450	18.2	3.04	3.23	1.91	2.06
Araras	CE	5000	63.7	1.70	1.84	0.99	1.09
Baixo Acu	RN	8000	127.0	1.76	1.91	1.03	1.13
Baixo Jaquaribe	CE	8400	104.7	1.13	1.24	0.68	0.77
Boacica	AL	4100	30.8	0.88	1.01	0.64	0.75
Ceará Mirim	CE	3320	42.0	2.47	2.64	1.53	1.66
Coreau	CE	2550	43.1	1.42	1.53	0.84	0.92
Corrente-Correntina	BA	10000	115.5	2.41	2.60	1.81	1.38
Corrente-Formosa	BA	7000	85.9	2.44	2.62	1.37	1.49
Curu-Paraipaba	CE	7000	133.8	0.56	0.66	0.30	0.37
Itapicuru	BA	9000	86.9	3.96	4.26	2.29	2.50
Jequitaí	MG	6300	112.1	0.40	0.48	0.18	0.23
Jequitaí-Pirapora	MG	6800	85.5	0.38	0.53	0.13	0.23
Lameiro	PI	13000	135.0	1.43	1.56	0.77	0.86
Marituba	AL	10000	89.0	0.36	0.43	0.14	0.19
Petrolina PA I	PE	6024	84.4	−0.18	−0.15	−0.41	−0.39
Rio Grande	BA	8000	109.0	1.22	1.35	0.49	0.56
Sistema BA	BA	5800	80.8	−0.19	−0.16	−0.45	−0.44
Sistema BB	BA	6400	101.5	−0.30	−0.27	−0.50	−0.48
Sistema BC	BA	2250	30.0	0.95	1.05	0.54	0.61
Sistema PA II	PE	7200	101.9	−0.21	−0.18	−0.46	−0.44
Sistema PD	PE	6500	89.2	0.86	0.98	0.32	0.40
Sistema PG	PE	5800	95.6	0.54	0.64	0.14	0.20
Vaza Barris	BA	2750	24.0	3.89	4.20	2.40	2.62

[a] State: AL = Alagoas, BA = Bahia, CE = Ceará, MG = Minas Gerais, PE = Pernambuco, PI = Piauí, RN = Rio Grande do Norte.

[b] Investment: Note that exchange rate in Nov. 1969 was 4.265 cruzieros/dollar.

[c] Benefit/Cost ratios: 10 percent or 15 percent = discount rate; M = market cost of labor, S = shadow pricing of labor.

The basic discount rate used in the analysis is 10 percent per annum. For sensitivity analysis, a rate of 15 percent is used as well. This range is commonly held appropriate for a country at Brazil's stage of development.[18]

Data for the study were obtained primarily from the Tahal and Sondotenica consulting firms which have analyzed irrigation policy for the Brazilian Ministry of Interior. Their data in turn were compiled from prior feasibility studies for some projects and estimated directly for others. Crop yields were cross-checked with data from experiment stations; prices were compared to those in available crop price reports. Minor revisions in yields and prices have been made where necessary. Demand constraint data are based on standard Brazilian crop production statistics [2].

Results

Table 1 presents the benefit-cost ratios for the 24 irrigation projects examined. With a discount rate of 10 percent per annum and using a shadow price on labor, 14 of the projects have benefit-cost ratios above unity. Their aggregate area (84,820 hectares) represents 55 percent of the area of the full set of 24 projects for which calculations were made. If it is assumed that a similar proportion of the remaining projects not examined directly[19] would be found favorable, the aggregate result would be that favorable Northeastern irrigation proposals reach a total of 108,000 hectares with investment cost of U.S. $305 million and annual employment of 64,000 workers (at full installation).

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[18] See [7, p. 184]. Note that further adjustments for divergence between social and private costs and benefits are omitted from the analysis. Due to lack of detailed data on imported equipment costs for each project, no adjustment is made for import costs, although a shadow price of foreign exchange of some 25 percent above the official rate might be justifiable in view of Brazilian protection rates [1]. On the other hand, the analysis also omits the indirect economic benefit of induced value added in processing and distribution activities, in excess of opportunity cost of factors to be employed in these activities (especially labor costs). The analysis excludes certain infrastructure costs (such as education, health, and housing facilities) on grounds that they would have to be incurred by the government even in absence of the project, or that their benefits definitionally equal their costs.

[19] Absence of certain data precluded application of the analysis to projects totaling approximately 50,000 hectares.

The difference between these results and those of the *PPI* study is primarily due to the fact that the linear programming optimal crop selection used here concentrates high value crops on the best soils. The original consultants' results are based on wider dispersion of high value crops over a large number of projects—turning more projects marginally profitable but lowering the excess of total benefits over costs for the projects considered in the aggregate.

With respect to shadow pricing of labor, it is noteworthy that of the 14 projects only two are favorable under shadow labor pricing but unfavorable under market (minimum wage) pricing. For all of the projects, shadow pricing of labor affects the benefit-cost ratios only marginally. Rather than implying that labor shadow pricing is unnecessary generally for project analysis in Brazil's Northeast, this result reflects the basic capital intensity of these projects.

The most important influence in the analysis is the time discount rate. At 15 percent discounting, of the 24 projects examined directly only 8 are favorable, representing only 30 percent of the aggregate project area and slightly more than half the area found favorable with 10 percent discounting.

Another feature of the results is their dependence on soil type. Almost all the projects with the better soils (*2s*, *2d*, *2st*) are found favorable under 10 percent discounting, while the projects dominated by the poorest soils (*3s*, *3st*, *4d*) are rejected under all criteria. While not surprising, this pattern does diverge from the original *PPI* results.

Concerning the crop patterns on the projects, the set of projects found favorable is dominated by the following products: potatoes (22 percent of output value), peanuts (20 percent), grapes (14 percent), beans (10 percent), tomatoes (9 percent), and pineapples (5 percent). All these except potatoes and beans represent full exhaustion of the quotas set as demand constraints.

Conclusion

The conclusion of this study is that slightly over half of the proposed area for irrigation in Brazil's Northeast appears to merit project approval from the standpoint of cost-benefit analysis, discounting at the reasonable rate of 10 percent per annum and imposing feasible demand constraints on individual crops. However, the projects do not offer a major solution to rural poverty in the Northeast since they would provide employment for only 64,000 workers, or less than 2 percent of the region's rural labor force.

In view of the limited employment prospects of the proposed projects, two caveats are in order. First, it is essential that the projects retain at least the degree of labor intensity contained in their originally anticipated small farm structure underlying the calculations presented here. There now appears to be some possibility that after completion the project areas would be sold to large agricultural enterprises, to minimize the government's institutional burdens. Such a revision would concentrate the benefits of the projects into the hands of an even smaller group and would have regressive income distributional implications.[20] Second, to the extent that the Brazilian government has at its disposal proposals for other projects (in agriculture or other sectors) yielding a return of 10 percent but having lower capital/labor ratios, consideration might be given to allocating investment funds to these other projects prior to committing funds to irrigation projects found favorable here.[21] In this case the logical approach would be to shorten the list of favorable projects by choosing those with the highest benefit/cost ratios first and to approve the remainder of the list only if investment funds remained unexhausted after allocation to more labor intensive investments with comparable rates of return.[22]

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[20] Note that some of the major irrigation proposals for the South of Brazil (notably in Camaquã, Rio Grande do Sul) are already planned to benefit an existing structure of very large farms. For many of the Northeastern projects, in contrast, the areas to be benefited are either already in small farm structures or are largely vacant lands; these projects, therefore, represent an opportunity for public investment with benefits which would not be constrained to follow skewed distribution imposed by pre-existing farm structure.

[21] Similarly, consideration could be given to labor intensive projects with return below 10 percent. However, choice of such projects would require explicit welfare function weights on employment objectives, whereas preference for more labor intensive projects with rates of return equal to those of favorable irrigation projects identified here would require no such welfare weights.

[22] The subgroup of projects found favorable at a 15 percent discount rate provides a first indication of an appropriately shortened list. Furthermore, since the time profiles of the various projects are comparable, there is little danger that this approach would unduly discriminate in favor of projects with early benefits.

References

[1] BACHA, E. L., AND R. L. MODENESI, "Custo Social das Divisas no Brasil, 1950–1969," Rio de Janeiro, IPEA, 1970, mimeo.

[2] Brasil, Instituto Brasileiro de Economia e Geografia, *Anuário Estatístico do Brasil*, Rio de Janeiro, yearly issues.

[3] Brasil, Ministério do Interior, Grupo Executive de Irrigação para o Desenvolvimento Agrícola-GEIDA, *Program Plurianual de Irrigação—PPI: Volume I, Relatório de Síntese*, Rio de Janeiro, 1972.

[4] Brasil, Ministério do Interior, Superintendência do Desenvolvimento do Nordeste, *Produto e Formação Bruta de Capital do Nordeste do Brasil 1965–1969*, Recife, 1971.

[5] CLARK, COLIN, *The Economics of Irrigation*, London, Pergamon Press, 1970.

[6] CLINE, WILLIAM R., *Economic Consequences of a Land Reform in Brasil*, Amsterdam, North-Holland Publishing Co., 1970.

[7] LITTLE, I. M. D., AND J. A. MIRRLEES, *Manual of Industrial Project Analysis in Developing Countries; Volume II: Social Cost Benefit Analysis*, Paris, O.E.C.D., 1969.

Joint Ventures and Family Labor Sized Farms*

KENNETH R. KRAUSE

Family labor sized farmers are experimenting with joint ventures to improve their incomes and staying power. Joint ventures supplement but do not replace existing cooperatives. Joint ventures are defined and conditions for success are suggested. Research and educational activities, particularly for extension economists, are discussed.

THIS note advances some arguments about joint ventures as a means of improving the staying power of family labor sized farms and also suggests ways in which agricultural economists, through research and educational efforts, can assist family labor sized farmers in using joint ventures.[1] The note specifically focuses on those farmers whose labor and management income is similar to that of middle management people in other industries.[2]

Recent large farm studies suggest that farm firms can become much larger than was thought possible a few years ago.[3] However, until sufficient economic and social indicators clearly show that a few large farms would better service society than many family labor sized farms, agricultural economists, especially extension specialists, can perform a needed service by helping to improve the staying power of family labor sized farms.

Joint ventures between farmers and between farmers and nonfarm investors appear to be increasing. The potential impact of widespread use of joint ventures among family labor sized farms could be substantial. If joint ventures developed to the extent that most family labor sized farms could obtain the same internal and external economies of size that very large farms obtain, about the same relative distribution of number and sizes of farm firms could be expected as now exist. However, some decrease in absolute numbers in each economic size group would likely continue to occur as some farm assets, particularly real estate, are transferred to nonfarm uses. Strengthened staying power of family farms could also serve to discourage large vertical and horizontally integrated nonfarm firms from starting to engage in farm production. Family farms may, however, enter into contract production agreements with agricultural processing firms and through joint ventures reduce production and product price risks and improve their staying power.

Joint Ventures in Agriculture

A joint venture can be defined as two or more people or firms (proprietors, partnerships, etc.) who come together for a specific economic purpose, creating a new legal entity in addition to retaining their previous legal entities. Joint ventures involve joint sharing of risks and income in proportion to the percentage ownership of assets owned in common. The joint venture may or may not be engaged in the same economic activities in which individual members are engaged. The specific form of legal business organization (general or limited partnership, sub-Chapter C or S corporations or cooperative) adopted by the participants depends on the nature of the joint venture, on the readiness of members to assume risks, and on their net worths and personal objectives.

A typical landlord-tenant lease arrangement, for example, is not a joint venture as defined in this note since a tenant does not typically maintain a separate legal entity [7]. In some cases, owner-operators who rent additional farming resources may create a joint venture by doing so. An acquisition of one firm by another

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[1] The many additional research and education activities and public programs that can have an impact on farm income and its distribution and on individual farm firm survival and growth are beyond the scope of this note.

[2] Extension economists often refer to this group of farmers whose gross sales fall in the $20,000–$100,000 category as "viable family farmers." Young farmers who lack sufficient resources to move out of low income situations, however, could be assisted by joint ventures.

[3] Over three-fourths of the current larger than family labor sized corn and wheat farms have been developed in the last decade and are not historical accidents that result from wealthy individuals buying large acreages of land decades ago and holding it together. While large farms will continue to increase in importance, they will not likely dominate production in the foreseeable future. Most new larger than family labor sized farms will evolve through consolidation and growth of present family labor sized farms [2, 3].

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usually does not constitute a joint venture since the acquisition is a takeover of an on-going firm for a specific purpose, and the firm which is acquired ceases to exist.[4]

Recent joint ventures appear to be taking on more formal arrangements. Increased awareness of legal liability, income tax reporting, and the use of credit are among factors that are encouraging farmers to formalize their joint activities. In addition, formal cooperatives that involve large numbers of farmers have increased in importance. Joint ventures between farmers and nonfarm investors or between nonfarm investors alone appear to be increasing [6].

Requirements of joint ventures

Joint ventures can succeed where economic needs and benefits can clearly be shown [5]. Most successful joint ventures involve the pooling of specific resources to permit specialization of the participant's labor and management contribution, obtaining joint control of resources, and improving the overall management and entrepreneurship of the joint venture participants. Some ventures require little restructuring of the participant's individual farm businesses, such as those formed to generate sufficient volume in order for participants to obtain a lower input purchase price or a higher selling price. Joint experimentation with seed varieties, fertilizer, new crops, livestock breeding, or machinery design can also be developed to help select or suggest improvements in the inputs used in individual farm businesses. These types of joint ventures obviously do not fall into specific categories.

Other joint ventures require specific business structures or the restructuring of existing farm businesses. For example, farmers specializing in grain production may join with firms specializing in livestock fattening and provide livestock feed inputs. Both would share in the management and entrepreneurship of the new firm with the objective of production and marketing of livestock. Another example might be several farm owners pooling all or part of their real estate assets in order to develop a large enough unit to attract a professional operator. In this way the owners might be able to obtain some of the internal economies and volume buying and selling advantages possible from a large scale operation. Each piece of real estate would be valued and common ownership established. Each contributor would lose title to his own property but would gain a percentage ownership of the combined real estate.

Joint farm production ventures can also involve nonfarmers such as active or retired businessmen who may have access to extra capital or under-utilized management abilities which could be productively employed in a joint venture. Nonfarm businessmen could find new business profit centers by, for example, providing machinery and equipment services to farmers and thus creating a new legal entity. Also, nonfarm businessmen in a high Federal income tax bracket might obtain some income tax deductions through joint ownership of machines and equipment and pass some of the benefits of the reduced tax costs on to the farmer-participants in the new organization.

In some cases existing tenant and landlord farming operations may provide a start toward substantive joint ventures. This is particularly the case where landlords have access to additional capital and could enter into joint ownership of machines and livestock with the farm operator. Landlords may be able, where necessary, to provide more management inputs themselves or hire the services of professional managers to complement their added capital inputs.

Joint ventures can encounter difficulties and thus not succeed in obtaining their full economic potential if farmers insist upon maintaining individual identity and do not try to compromise to arrive at a group decision. Thus, an important ingredient to success of a joint venture is the individual participant's commitment to abide by the group decision. This involves surrendering some individual sovereignty to the group—something which some family labor sized farmers may continue to be reluctant to do. This is particularly the case if their production and marketing practices would be directly affected. However, the type of joint ventures affecting only purchase and sales practices decisions might be easier for family labor sized farmers to accept than those involving their entire farm business. For instance, joint purchase of fertilizers or crop chemicals requires little modification of operational decisions while a joint dairy cow milking venture may involve major change since part of the labor and management input may be provided by other than the individual participants in the joint venture.

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[4] The use of a specific definition of a joint venture for purposes of this paper should *not* be interpreted as though the author intends to imply that large payoffs from research and extension efforts cannot be made from improving existing tenant and landlord leases, or from combining farms or from assisting farmers in leasing or hiring machine services or livestock.

Achievement of goals

There is increasing interest among farm leaders in developing enabling legislation to allow farmers to bargain collectively with purchasers of their products. If such legislation allows small groups of family labor sized farmers to bargain with processors, farmers could develop joint ventures to do so. Several variations could evolve with the simplest being a small group of family labor sized farmers who join together in a new legal entity to agree on a price for the product that each produces. More complex forms involve each farmer agreeing on a production quota in order to participate in the joint venture and may also involve storage of excess production for future sale.

Individual farmers may be unable to overcome some of the new environmental standards, particularly with respect to animal waste pollution. The cost of meeting the new public requirements may exceed the potential returns from an existing enterprise. In such cases, individual farmers may abandon their own livestock facilities and through joint ventures with other farmers construct new facilities that meet environmental standards and that also can generate acceptable returns on the investment.

The potential to expand agricultural output and processing exists in many rural communities and can serve as a basis for increasing employment opportunities and rural income. Thus, several of the possible joint ventures that are mentioned in this note can be considered as rural development efforts as well as efforts to assist family labor sized farmers.

Number and Type of Participants

One prerequisite for joint venture success is a thorough analysis of input and product markets. Maximum discounts on purchased inputs such as the same or similar analysis fertilizer may depend on the volume and timing of the purchase rather than on total dollar purchase. Large volume procurers of farm products likewise may be willing to pay premiums to obtain a large volume and uniform quality at specified times. Given that similar specification is critical to volume buying and selling advantages, similar sized farms that specialize in similar type production appear to have the greatest opportunities to succeed with buying and selling joint ventures. Small and family sized farmers often do not specialize in one or two farm products, and their needs are different from specialized large farms. Joint ventures could be helpful for small and socially and economically disadvantaged farmers but, since their abilities and motivations are substantially different from commercial sized farmers, extensive public help may be needed to improve their economic positions [4].

The number of participants in most joint ventures of the type suggested here probably would be quite small in most cases, usually under 10 participants. Opportunities such as extra discounts on purchased inputs or premiums for volume sales develop rather rapidly and have a short opportunity life. If full group participation is required to capitalize on such opportunities, the group needs to be relatively small in order to make group decisions quickly.

Ten 500 acre or five 1,000 acre feed grain producers in the Midwest should be able to obtain most of the buying, conditioning, storage, and selling advantages that are possible [1,3]. A joint venture with fewer participants or a smaller volume could be successful if a manager is employed who is highly skilled in buying and selling negotiations. In fact, only two farmer participants may be necessary in joint venture activities involving custom machine services, conditioning, storage, or livestock raising or fattening.

Management and Organization

Joint venture participation need not imply that family farmers should diversify or that diversification of management or addition of enterprises to the farmer's portfolio of assets is more profitable than specialization. Depending on the type of joint venture and how it is operated, individual farmer participants may be able to become more specialized or to diversify. For example, if a farmer enters into either an "input buying" or "grain conditioning and storage" joint venture, he may be selected as the manager of the venture, in which case he would be diversifying his management. If he is only a participant and someone else manages the venture, the non-manager participants may be able to specialize their talents more in grain production and spend less energy in buying, conditioning, and storage activities. A farmer may diversify by entering a new joint venture, e.g., a cash grain farmer may enter a new cow milking venture where he may be the manager or provide some of the feed input from his own grain production.

The leadership may come from one or all joint venture participants. Where several activities are involved in a joint venture, individual participants may each be responsible and provide the leadership for one activity. If the potential economic benefits are large enough and members of the joint venture lack the necessary time or expertise, a part-time or full-time manager may be hired to provide the necessary leadership subject to the participants' control. In some cases, a family labor sized farmer who is not fully employed but who possesses management, negotiating, and service skills may be employed to manage the venture. Farm representatives employed by commercial banks and farm business associations may also be useful leaders and directors of joint ventures.

Management decision rules need to be fully developed and agreed upon by all participants in formal joint ventures. Such rules are necessary to provide guidance when disagreements develop among members and when it would be to a particular member's advantage not to participate in a particular activity at a given time but yet a disadvantage to the entire membership if he did not participate.

Low Income Farmers

Development of institutional arrangements and educational activities for low income farmers is receiving more attention among agricultural economists. Since there are several subsets of low income farmers, an unqualified answer should not be given on the advisability of using joint ventures to solve low income problems [4]. However, given the definition of a joint venture used in this note, low income farmers would need some assets that they could put into a new joint venture in order for a joint venture to be created and to exist long enough for participants to benefit substantially.

One subset of low income farmers who can benefit from joint ventures without special public assistance are the younger or beginning farmers who lack sufficient resources to move rapidly out of low income situations. Such farmers could, for example, enter into joint ventures with and be helped especially by nonfarmers who have extra capital or underutilized management.

Low income farmers of any age who have management ability that has not been developed can be helped through intensive public education efforts. An efficient use of public resources may be to use, for instance, extension, Farmers Home Administration, or Bureau of Indian Affairs personnel as managers of joint ventures. Such personnel would thus be helping farmers to make decisions while teaching in real farm business decision settings and reaching the several farmers who would be members of such ventures.

Joint ventures should probably not be encouraged for older low income farmers or those who lack the ability to work with other farmers. Older, low income farmers often do not desire higher incomes and expect to survive at least in part from Social Security income. About two-thirds of the low income farm families who receive credit from the Farmers Home Administration have severe personality problems that are impediments to increasing their income [4]. Intensive individual supervision from the Farmers Home Administration is necessary for such farm families and especially in cases where other lines of employment are not possible.

Assisting Joint Ventures

Developing feasibility studies, guidance publications, and operational consultation for farm joint ventures is outside the emerging domain of many agricultural economists [2, pp. 757–759]. However, applied research-extension personnel in land grant universities, private industry, and foundations may find that research and educational activities on joint ventures provide a relatively new challenge. Public research and education expenditures on joint ventures can, at least in part, be defended on the basis that very little information is available on the opportunities and problems for family labor sized farm joint ventures.

The potential for joint ventures exists in most states and economic regions and is not limited to particular commodities or types of farm businesses. Thus, a useful way to start studying joint ventures is to form a task force or team of land grant school and other agricultural economists at the state, regional, or national level. Since joint ventures involve legal, accounting, tax, and personality problems, expertise from several fields would be useful in studying joint venture problems and in providing educational assistance. Thus, the inclusion of people with legal, accounting, industrial psychology, and management systems training and experience from schools of business and finance at the outset of the team effort would be useful.

The task force or team would begin with conceptualization and determine what is known about joint ventures, what needs to be known, what is working now, what has been tried, and what has failed. Analysis of firm growth that has been achieved by joint ventures and by farmers who have not used them should be useful in determining the magnitude of public and private resources that should focus on joint ventures.

As part of a general effort to determine what works and what are potential problems, analysis of joint ventures outside the farm sector should be undertaken too. From such preliminary efforts, target groups of potential joint venture farmers could be identified. A second phase would include developing task forces or teams with specific research and education objectives to carry out the objectives. In addition, publicly supported consultation needs for farmer joint ventures could be determined.

Joint Ventures and Established Cooperatives

Theoretically, the existing systems of farmer cooperatives are joint ventures since they are a separate legal entity that two or more farmers created. They provide farmers with low cost purchased inputs and some custom services. Cooperatives help farmers by providing aggregate clout at the manufacturer and processing level and in state and national public policy areas and thus fulfill a useful role. Existing cooperatives may help farmers to obtain relatively low average input costs or higher average market prices or to obtain some custom services that would not otherwise be available. However, they are not structured to maximize economic returns for individual or small groups of farmers nor do they generally jointly share production or product conditioning and marketing risks with their members.

When small cooperatives stock a wide range of inputs, they do not concentrate buying power. They do not necessarily concentrate service work since they use machines and equipment that will service the average member. Marketing power for farm products is frequently not developed at the local cooperative level since cooperatives often sell feed grains, for example, back in small job lots to local firms. Marketing power, however, is developed in livestock or in fruits and vegetables when the cooperative can assemble large quantities of specified products to sell to processors or retailers.

Cooperatives design their policies with some flexibility to serve their average member and often do not employ the most aggressive management. Since the cooperative, as an organization, tries to obtain firm growth, it requires a margin of profit on its activities for growth. This margin is not returned directly to individual members.

Summary

The type of joint ventures used as examples in this paper fall between big cooperatives and informal buying and selling efforts of several farmers. Cooperatives are joint ventures in that members keep their own legal entities as well as entering into a separate legal entity—the cooperative. In general, joint ventures among a small group of farmers do not replace existing cooperatives but rather supplement them to meet farmers' economic needs. A group of farmers, for instance, may form an input purchasing joint venture and through specification and quantity purchases improve their own profits but, by doing so, they do not necessarily weaken the existing cooperative. The joint venture group by taking a specified quantity of an input at a specified time may improve the technical efficiency of the input distribution system by reducing the number of times the input is handled and its storage requirements. If joint ventures should become strong in grain conditioning in a local geographic area, for example, they could replace this function that a small local cooperative provides. However, local cooperatives could join together to form regional grain terminals which in turn could assist local joint ventures through very large volume selling to processors.

References

[1] FARIS, J. EDWIN, AND DAVID L. ARMSTRONG, *Economies of Size, Kern County Cash-Crop Farms*, Giannini Foundation Res. Rep. 269, University of California, Dec. 1963.

[2] KRAUSE, KENNETH R., AND LEONARD R. KYLE, "Economic Factors Underlying the Incidence of Large Farming Units: The Current Situation and Probable Trends," *Am. J. Agr. Econ.* 52:748–760, Dec. 1970.

[3] ———, *Midwestern Corn Farms: Economic Status and the Potential for Large and Family Sized Units*, USDA ERS AER-216, Nov. 1971.

[4] KRAUSE, KENNETH R., AND PAUL L. WILLIAMS, "Personality Characteristics and Successful Use of Credit by Farm Families," *Am. J. Agr. Econ.* 53:619–624, Nov. 1971.

[5] OSTER, MERRIL J., "Joint Ventures that Work," *Agr. Finance* 14:4–8, May–June 1972.

[6] SCOFIELD, WILLIAM S., "Nonfarm Equity Capital in Agriculture," USDA ERS *Agr. Finance Rev.* 33:36–41, July 1972.

[7] ———, "The Farm Scene: Where Partnerships Fit In," USDA ERS *The Farm Index* 11:4–6, Jan. 1972.

Labor Productivity in Apple Harvesting

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Selected worker characteristics and grower management practices were analyzed by OLS regression to determine their relationship to the productivity of workers hand harvesting apples. Growers should be able to shorten harvest time by selecting workers with characteristics related to higher productivity and by using management practices associated with faster picking.

MANY fruit and vegetable crops grown in the U. S. are harvested by seasonal hand labor which has traditionally been paid on a piecework basis. Recent reductions in the total number of seasonal workers available for employment on U. S. farms [3, p. 34] have resulted in growers experiencing the following two problems, among others: first, difficulty recruiting harvest labor and, second, difficulty harvesting a crop during the period of peak quality.

Objective and Purpose of Study

The objective of this study was to analyze factors related to the productivity of workers being paid on a piece-work basis for hand harvesting apples. Three categories of variables were selected for this purpose: variables describing worker characteristics, variables under the control of the grower within a harvest year, and variables not controllable by the grower within a harvest year.

Identification of worker characteristics associated with higher labor productivity in harvesting apples should aid growers in recruiting harvest workers. Utilizing practices related to higher labor productivity in apple harvesting should reduce the time required to harvest a given quantity of apples with a given number of workers. This should be true whether the practice is one which can be adopted during a given harvest season or one which can only be included in longer range planning.

Method of Analysis

Ordinary least squares regression analysis was used to analyze the relationship between the rate at which workers harvested apples by hand on a piece-rate basis and selected independent variables. Data on 560 worker units picking apples by hand on a piece-rate basis in Michigan were utilized in the regression analysis.[1]

The dependent variable (Y) and the independent variables included in the regression equation were defined as follows:

Y = bushels of apples picked per hour per person.

Worker Characteristics

Worker unit age

$X_1 = 1$ if worker age less than 26, $= 0$ if worker age 26–50,[2]

$X_2 = 1$ if worker age over 50, $= 0$ otherwise.

Worker unit sex

$X_3 = 1$ if worker unit female, $= 0$ if male,

$X_4 = 1$ if worker unit included both male and female, $= 0$ otherwise.

Worker unit experience

$X_5 = 1$ if less than two years apple picking experience, $= 0$ if two or more years.

Worker unit ethnic origin

$X_6 = 1$ if black worker unit, $= 0$ if white,

$X_7 = 1$ if Mexican or Puerto Rican worker unit, $= 0$ otherwise.

Worker unit residence

$X_8 = 1$ if Michigan resident, $= 0$ otherwise.

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[1] A worker unit consisted of one person working alone or two or more persons working together and pooling their apples. Data used in this analysis were collected in 1965 by the Rural Manpower Center, Michigan State University, and included 3,982 worker-day observations consisting of the number of bushels of apples picked each day by each worker unit in addition to information on variables hypothesized to be related to worker productivity for each day [1, pp. 17–20].

[2] Certain categories of "dummy" variables have zero values for all observations and were omitted in solving for the regression coefficients [2, 4].

Variables Growers Can Control within Harvest Year

Type of picking

$X_9=1$ if all apples picked with stems on, $=0$ if apples picked without regard for stems.

Degree of tree pruning

$X_{10}=1$ if trees well pruned, $=0$ otherwise,
$X_{11}=1$ if some to moderate tree pruning, $=0$ otherwise.

Type apple market

$X_{12}=1$ if apples picked for retail market, $=0$ if apples picked for processing.

Rate of pay

$X_{13}=$ rate of payment to workers per bushel in dollars.

Bonus payments

$X_{14}=1$ if no bonus paid to workers, $=0$ otherwise.

Type of supervision

$X_{15}=1$ if close supervision of pickers, $=0$ if little or no supervision of pickers.

Type of picking equipment

$X_{16}=1$ if metal picking equipment used, $=0$ otherwise.

Worker unit size

$X_{17}=1$ if worker picking alone, $=0$ otherwise.

Variables not Controlled by Growers within Harvest Year

Tree age

$X_{18}=$ age of tree in years.

Typography of orchard

$X_{19}=1$ if orchard level to gently rolling, $=0$ if orchard hilly.

Harvest weather conditions

$X_{20}=1$ if weather conditions good, $=0$ otherwise.

Tree spread

$X_{21}=$ tree spread in feet.

Tree height

$X_{22}=1$ if tree height over 18 feet, $=0$ if tree height 14–18 feet.

Table 1. Regression coefficients and standard errors for regression equation

Variable	Regression coefficient	Standard error	Variable	Regression coefficient	Standard error
Constant	14.845**	1.046	X_{12}	−0.938**	.185
X_1	−0.425**	.162	X_{13}	−0.174**	.025
X_2	−2.007**	.218	X_{14}	.478*	.214
X_3	−1.651**	.253	X_{15}	.728**	.173
X_4	−1.281**	.317	X_{16}	1.343**	.318
X_5	−2.093**	.148	X_{17}	1.292**	.296
X_6	−1.181**	.182	X_{18}	−0.046**	.005
X_7	.146	.205	X_{19}	.743	.647
X_8	−1.005**	.180	X_{20}	−0.719**	.128
X_9	−0.806**	.202	X_{21}	−0.006*	.003
X_{10}	−0.235	.251	X_{22}	−0.182	.185
X_{11}	.464*	.209	X_{23}	−0.138	.157
	$R=0.4368$			$\bar{R}=0.4314$	

* Significantly different from zero at the 0.05 level.
** Significantly different from zero at the 0.01 level.

Fruit size

$X_{23}=1$ if over 175 apples per bushel, $=0$ if 125–175 apples per bushel.

Results and Implications of Analysis

Although the proportion of variation in apple picking rates explained by the regression equation was relatively low, several variables were significantly related to worker productivity (Table 1). Statistical significance does not necessarily imply that a variable will be economically important, but it should suggest factors which apple growers should evaluate in the selection of harvest workers and in the management of their orchards.

Worker Characteristics

The results suggest that the productivity of apple pickers differs significantly by worker age, sex, experience, ethnic origin, and residence.

Workers aged 26–50 years old picked roughly .5 bushel more apples per hour than younger workers and approximately 2 more bushels of apples per hour than older workers on the average. Male workers averaged picking over 1.6 more bushels of apples per hour than female workers and over 1.2 more bushels of apples per hour than mixed male and female worker units.[3] Less than two years of experience picking apples was associated with average worker picking rates approximately 2 bushels per hour slower than was two or more years of experience.

Picking rates of white and Mexican or Puerto Rican workers were not significantly different rom each other, but both these groups of workers had average picking rates over 1 bushel per hour faster than black workers. Migrant workers picked about 1 more bushel of apples per hour on the average than Michigan resident workers.

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[3] The simple correlation between X_4 (mixed male and female workers) and X_{17} (worker picking alone) was −0.88. Therefore the regression coefficients for these two variables should be interpreted with caution.

Given that a grower could select only a imited number of workers to harvest apples and that timeliness of harvest is an important consideration, he should select workers with characteristics associated with faster picking rates. Based on the results of this study, workers with the fastest picking rates can be characterized as migrant Mexican or Puerto Rican males between 26 and 50 years old with at least two years of apple picking experience.[4]

Variables Growers Can Control Within Harvest Year

Several variables included in the regression equation which were assumed to reflect factors a grower can control during an apple harvest season were significantly related to apple pickng rates.

When workers were required to pick apples n such a manner that stems remained on all apples, their average productivity was almost 1 bushel per hour lower than when apples were picked without regard for stems. A moderate degree of tree pruning was associated with apple picking rates almost .5 bushel per hour higher on the average than was little or no pruning, but worker productivity levels in well pruned trees were lower than in trees with ittle or no pruning.[5] Picking apples for sale on he retail market as fresh fruit reduced average apple picking rates by almost 1 bushel per hour below rates achieved when apples were picked or processing.

The two variables connected with payment of harvest workers had estimated regression coefficients which may appear contrary to *a priori* expectations. An increase in the rate of payment to workers per bushel of apples picked was associated with a decrease in worker productivity.[6] Workers who received a bonus payment for each bushel of apples harvested averaged picking approximately .5 bushel fewer apples per hour than those who received no such payment.[7]

Workers who were closely supervised picked roughly .75 bushel more apples per hour on the average than those who were not closely supervised.[8] Picking rates of workers who were furnished metal picking equipment averaged over 1 bushel per hour more than those of workers using canvas or other types of equipment.[9] And pickers who worked alone, as opposed to working in groups of two or more, picked over one bushel more apples per hour on the average.[10] Apple growers should be able to increase the productivity of their harvest labor by close supervision of workers, providing workers with metal picking equipment, and placement of workers so they pick individually instead of in groups.

Picking apples for the fresh market and practices associated with the production of fruit for this market tend to lower the productivity of pickers. Therefore, if harvest labor is in short supply, growers should consider more than the addition to price per bushel which the retail market may provide. When choosing a market outlet, growers should also consider the possible loss of a portion of the crop due to slower picking rates.

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[4] This statement is based on statistically significant differences in all cases except one. Picking rates of white worker units were not significantly different from those of Mexican or Puerto Rican units.

[5] The influence of tree pruning on the productivity of workers is difficult to assess, *a priori*. One would hypothesize that a well pruned tree should be easier to pick. Howver, to the extent that a high degree of pruning is associted with an attempt to produce large, highly-colored fruit for the fresh market, expected productivity might be lower.

[6] This result may have two possible explanations. First, and most likely, growers commonly adjust the amount they offer workers for picking apples in accord with picking conditions. This variable may represent a proxy variable for picking difficulty based on the subjective judgments of growers and pickers. Second, the goal of pickers may be such that they desire some relatively fixed income level. Given this condition, pickers would be able to reduce their picking rates and still attain their income goal if the rate of payment per bushel was raised.

[7] This result may also be explained by picking difficulty. The bonus payment as used by most growers generally consists of a part of the total payment to workers being withheld until the end of the harvest season. It is designed to discourage workers from moving to other orchards after picking only that portion of the crop which yields the highest labor return per hour. Interpreted in this manner, the bonus payment is a compensation to workers for picking under conditions which tend to reduce worker productivity.

[8] The degree of supervision was subjectively evaluated in the field. Part of the increase in worker productivity attributed to supervision most likely resulted from growers or other supervisors assisting workers with tasks such as moving picking crates.

[9] The simple correlation between X_{16} (metal picking equipment) and X_{18} (tree age) was -0.65. Therefore the regression coefficients for these two variables should be interpreted with caution.

[10] See footnote 3.

Variables not Controlled by Growers Within Harvest Year

Variables included in this category do not appear to be as important as the previous category of variables for apple growers to consider in the operation of their orchards for two reasons: growers cannot control a variable such as weather, and all other variables were either not statistically significant or the magnitude of their effect on worker productivity was negligible.

Both tree age[11] and tree spread were negatively related to the number of bushels of apples picked per hour by workers. These should, therefore, be factors for growers to consider in long range planning even though the magnitude of their effect on worker productivity was rather small.

Weather cannot be controlled by a grower, but it was significantly related to worker productivity. Workers picked fewer bushels of apples per hour under the conditions defined as "good" weather in this study than they did under weather conditions defined as "bad."[12]

Other variables in this category were not significantly related to worker productivity.

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[11] See footnote 9.

[12] The empirical result of the analysis of the weather variable did not conform to *a priori* expectations. There may be two possible explanations for this unexpected result. First, the determination of what constituted "good" weather was made by Michigan residents who were white [1, p. 26]. They may not have been aware of what was considered "good" weather by nonresidents of Michigan or other ethnic groups. A second possible explanation is that weather had no significant influence on the performance of a given individual but determined the make-up of the sample of workers observed on different days. Thus, worker units observed under "bad" weather conditions may have been only one segment of all workers observed—those who were regular pickers with this activity as their sole means of support. Part-time workers, women, and children may have chosen not to pick under disagreeable weather conditions.

References

[1] CUSKADEN, CHARLES M., "An Analysis of Worker Productivity in Apple Picking," unpublished Ph.D. thesis, Michigan State University, 1971.

[2] JOHNSTON, J., *Econometric Methods*, New York, McGraw-Hill Book Company, Inc., 1963.

[3] METZLER, WILLIAM H., RALPH A. LOOMIS, AND NELSON L. LEROY, "The Farm Labor Situation in Selected States, 1965–66," USDA ERS *Agr. Econ. Rep.* 110, April 1967.

[4] TOMEK, WILLIAM G., "Using Zero-One Variables With Time Series Data in Regression Equations," *J. Farm Econ.* 45: 814–822, Nov. 1963.

Agricultural Trade Intensity: The European Markets and the U. S.

M. K. CARNEY

To examine developments in agricultural trade between countries in EEC and EFTA, the U. S., and an aggregate of other countries, a measure of trading intensity is calculated for years from 1960 through 1969. Intra-EFTA trade intensified; EEC trade did not. U. S. trade with the remainder of the world intensified.

THE purpose of this study is to examine agricultural trade among members of the European Economic Community (EEC), the members of the European Free Trade Association (EFTA), and the United States (U. S.), during the 1960's.[1] This time period encompasses both the moves toward increased discrimination[2] as the two markets implemented tariff and other commercial policies and the move toward decreased discrimination following the Kennedy Round agreements.

Agricultural trade[3] is examined using a particular measure of trading intensity which has been estimated for each year from 1960 through 1969. The intensity of trade between individual nations is considered, as well as the intensity of trade among groups of nations.

Theory of Discrimination

Recent contributions [6, 10] to the theory of discrimination have taken the form of general equilibrium analysis employing a three-country and two-good model. Two countries with either similar (each exports the same good) or dissimilar (each exports a different good with one of these being the collective export of the pair) exports engage in discrimination. Series of cases have been analyzed for varying circumstances such as similarity and size of countries, capital mobility, and degree of discrimination. A wide range of outcomes is possible as circumstances are varied. Kemp refers to the "rich variety" of possibilities [6, p. 123]. For example, in certain cases trade within the market may expand, contract (even to the point of extinction), or stay the same; trade reversal is possible. Nevertheless, it seems most likely that, in a multi-good world, trade within the area of discrimination will expand, trade between the union and the rest of the world will contract, and trade among nations outside the union will expand,[4] all else held constant.

The expectation for trade among EFTA, the EEC, the U. S., and the remainder of the world[5] (ROW) prior to the Kennedy Round would be that trade within both EFTA and the EEC would intensify, as would trade between the U. S. and ROW. The intensity of trade would be expected to decline between EFTA and the EEC. Nations in EFTA and the EEC experience double discrimination, that is, discrimination from joining one market and thus being excluded from the other market. Both sources of discrimination are expected to have the same impact on trade intensity in the above cases. In the case of trade of each market with the U. S. and ROW, the expectation differs with the source of discrimination. For example, EFTA (EEC) trade with ROW and the U. S. should decline in intensity as a result of EFTA (EEC) discrimination and intensify as a result of EEC (EFTA) discrimination. Implementation of the Kennedy Round, to the extent that EEC and EFTA discrimination was reduced, would be expected to reverse the impact of that discrimination.

Much of the theoretical literature involving discrimination is set in the framework of welfare analysis focusing upon the concepts of trade creation or trade diversion originated by Viner [11]. Intensification of trade as defined in this paper refers to a positive rather than a welfare phenomenon and cannot be equated

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[1] Full members of EFTA are Austria, Denmark, Norway, Portugal, Sweden, Switzerland, and the United Kingdom. EEC members are Belgium-Luxembourg (reporting combined data), France, Germany, Italy, and the Netherlands.

[2] Discrimination refers to all preferential trading agreements, i.e. tariffs, quotas, and other measures influencing trade.

[3] Agricultural trade is defined in this paper as trade in SITC Section 0.

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[4] The three-country model does not permit analysis of trade among countries outside the union, but Meade [7, p. 525] earlier predicted a "secondary, secondary stimulation of trade" among them.

[5] The remainder of the world refers to all nations other than the members of EFTA and EEC and the U. S. This terminology is used to distinguish this group from the rest of the world in the theoretical literature where it refers to all countries outside of a market.

with either trade creation of diversion. In fact, both trade creation and diversion within a market would result in trade intensification within the market. However, Kemp's use [6] of the term "trade creation" closely parallels intensification as used here.

Discriminatory Policies

Beyond the fact that both markets set aside agricultural goods for separate treatment, their respective policies affecting these goods have little in common.

EEC

The Common Agricultural Policy (CAP) has been widely publicized, in part because of the marathon sessions necessary in the achieving of it, and in part because of the fear of the discriminatory features of it. Early in 1962 the CAP was established in principle. It defines a unified or single market characterized by common prices and without internal or external tariffs but a market highly protected by variable import levies. Implementation of the CAP has been in stages beginning in 1964. The EEC reached the single market stage for cereals, pork, eggs, poultry, and rice in 1967 [2, p. 149]. Single markets are defined for beef, veal, milk, fruits, and vegetables, oils, fats, sugar, and wine. Internal tariffs have been removed, and the Common External Tariff has been established on agricultural products exempted from tariff reduction but not yet subject to a common organization of the market.

EFTA

Despite the exemption in the EFTA convention of goods listed in Annexes D and E [5] from tariff reduction, such reduction remains the most important commercial policy affecting trade in agricultural goods in EFTA. First, the list of exempted foods was somewhat shorter in EFTA than in EEC. Frozen fish fillets (important for Norway), tomato paste (important for Portugal), and other items have been subject to multilateral tariff reduction since 1960. Second, selective tariff reduction, that is reduction of tariffs by one or more but not all members has taken place as a result of both bilateral agreements and a Council decision in 1966. However, the bulk of items is unaffected.

The bilateral agreements contain non-tariff elements also. The importance of these elements is difficult to assess. For example, the Austrians agreed to "recommend importers pay increased attention" to Danish goods, and the Swiss agreed to grant import licenses for Danish pork by weights instead of pieces [4].

Kennedy Round

The Kennedy Round of tariff negotiations was completed simultaneously with final discussion of the CAP. The U. S., and to a lesser degree Denmark, were the nations most interested in obtaining concessions for their agricultural exports. The results of negotiations with the EEC over agricultural goods were officially "more modest than the results in industry." However, the U. S. State Department reported significant agricultural concessions from Japan, Canada, the UK, Scandinavia, and Switzerland [3]. Tariff reductions on affected items began in 1968, with the U. S. reducing tariffs by 20 percent on January 1, 1968, and European nations reducing tariffs by 40 percent on July 1, 1968. The U. S. made its second 20 percent cut at the beginning of 1969.

Method of analysis of intensity

A measure of trading intensity developed by Savage and Deutsch [8] is employed.[6] A $K \times K$ matrix T of actual trade for a given year is such that t_{ij} is the dollar value of the ith nation's export to j ($t_{ij}=0$, when $i=j$). From the information in T the hypothetical "probabilities" associated with nations exporting P and importing Q are estimated in an iterative process. The expected trade shipment moving from i to j based on origin-destination independence is

$$\hat{t}_{ij} = \begin{cases} Sp_iq_jT, & \text{where } i \neq j \text{ and } T \text{ is total} \\ & \text{world exports (imports)} \\ 0 & \text{where } i = j \end{cases}$$

$$S = (1 - \Sigma p_k q_k)^{-1}.$$

T and $\hat{T}$ are then compared and a matrix of trading intensity NI created such that $ni_{ij} = 100 t_{ij}/\hat{t}_{ij}$, where $0 < ni_{ij} < \infty$.[7] The measure thus described is an index of trading intensity where 100 implies that actual and expected trade are equal. Expected trade from i to j is based solely on the size of i's exports and j's imports. Divergences of actual trade from expected trade in the base year reflect geography, taste, and comparative advantage.

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[6] See Savage and Deutsch [8] for elaboration of this method and Carney [1] for use of method examining total trade of EFTA, EEC, and the U. S. Taplin [9] compares this method with alternative methods.

[7] Savage and Deutsch used $(t_{ij}-\hat{t}_{ij})/\hat{t}_{ij}$, which illustrates the similarity of this approach to a chi-square contingency table.

When the change of intensity is used in this paper, it is defined as $(n_{ij_T}-n_{ij_0})$, with additional subscripts indicating time periods. Trade intensifies when actual trade increases faster than expected trade. Since expected trade increases with the secular growth in trade, growth *per se* will not cause intensification. Similarly, a decline in exports *per se* caused by crop failure or strikes will not affect intensity. Change in intensity over time is a measure that enables one to compare the outcome, observed in a dynamic environment, with the theoretical expectation, set in a comparative static framework. Changes in intensity could be caused by a variety of factors, one of which is the implementation of discriminatory commercial policies. Trading intensities were also estimated for groups of nations such as the members of EFTA, the members of EEC, and others in the manner proposed by Savage and Deutsch.

For this study the matrix T is 14×14 with the member nations of EEC and EFTA introduced individually along with the U. S. Trade data from *Trade by Commodities*, Series C, Organization for Economic Cooperation and Development, are used.

Changes in intensity of trade

The results of greatest interest are shown in Tables 1 and 2. The theoretical expectations in light of the policies implemented by the markets are largely met during the period from 1960 through 1969.

From the perspective of EEC discrimination, all of the results are consonant with expectations with the possible exception of the behavior of intra-EEC trade itself. The intensity of this trade fluctuated but on balance declined. EEC policy appears to have encouraged autarky; agricultural output increased, but internal trade did not intensify.

Changes in the intensity of trade flows between EFTA and the U. S. and EFTA and ROW are more compatible with EEC discrimination than with EFTA discrimination. Of these four trade flows, only that of EFTA imports from the U. S. declined in intensity, which would be the expected outcome of EFTA discrimination. Thus the lack of intensification of intra-EEC trade does not appear to reflect a non-discriminatory impact as far as nations outside of EEC are concerned.

While it is difficult to attribute the intensification of intra-EFTA trade to the sketchy agricultural arrangements within EFTA, it appears that the trading developments are compatible with the EFTA arrangements, as well as EEC policy.

Trading patterns from 1967 through 1969 would reflect any impact on trade from tariff cuts following Kennedy Round negotiations. The evidence is mixed. Trade within EEC and EFTA showed no clear trend, and trade between them continued to weaken in intensity. Trade between each market and the U. S. was also mixed. U. S. exports to the UK and Switzerland intensified while exports to other EFTA members cited as granting concessions

Table 1. Index of intensity of agricultural trade within the unions (expected trade = 100)[a]

Trade \ Years	60	61	62	63	64	65	66	67	68	69
Intra-EEC	252	248	242	250	252	233	248	246	251	238
Fra to EEC	182	190	183	204	207	199	233	236	237	245
Ita to EEC	246	246	244	246	254	242	248	222	220	201
Net to EEC	279	274	262	269	274	249	254	246	250	228
B-L to EEC	341	333	316	318	319	277	277	286	298	276
Ger to EEC	302	284	264	248	242	212	235	281	293	261
EEC to Fra	207	180	187	221	244	220	216	218	247	245
EEC to Ger	292	293	283	300	297	269	298	287	277	256
Intra-EFTA	182	186	189	197	207	201	222	215	232	222
Den to EFTA	224	232	235	239	255	246	273	269	282	275
Nor to EFTA	150	169	161	170	183	194	188	191	217	207
For to EFTA	87	90	101	102	114	116	135	125	143	138
PETA to UK	190	189	190	191	202	200	226	211	224	209
Intra-Scan	303	366	341	362	393	406	403	442	522	535

[a] Source: *Trade by Commodities*, Series C, OECD. See text for method of derivation and definitions of expected trade and intensity index.

Table 2. Index of intensity of agricultural trade between the unions and the rest of the world and within the rest of the world[a]

Trade / Years	60	61	62	63	64	65	66	67	68	69
EEC to EFTA	91	91	90	93	89	84	82	79	71	62
Net to EFTA	85	86	84	86	79	73	75	73	67	61
EEC to UK	61	61	56	55	54	49	50	50	45	40
EEC to US	26	25	23	22	21	20	22	22	19	16
EEC to ROW	67	67	66	61	60	59	56	54	54	50
EFTA to EEC	150	144	135	141	132	117	110	103	94	84
Den to EEC	158	149	132	142	125	106	97	82	82	73
EFTA to Ger	207	201	173	174	151	138	126	105	100	86
EFTA to US	36	40	42	42	40	44	52	52	55	59
EFTA to ROW	62	64	63	57	59	63	62	67	71	80
US to EEC	63	75	74	67	67	72	67	63	69	50
ROW to EEC	80	76	79	78	78	76	78	75	71	70
US to EFTA	52	43	50	39	40	38	41	37	32	34
ROW to EFTA	105	108	107	108	108	111	110	111	114	118
US to ROW	146	144	144	152	151	157	154	165	171	191
ROW to US	120	122	122	123	124	129	126	129	132	138

[a] See Table 1 note.

declined [3]. The one consistent trend during this period was the intensification of trade between the U. S. and ROW, especially U. S. exports to ROW. This development may reflect concessions by Japan and Canada or it may reflect increased discrimination with the final implementation of the CAP. The conclusion from this study is that the gloom associated with the Kennedy Round results in agriculture was not misplaced, at least through 1969.

References

[1] Carney, M. K., "Developments in Trading Patterns in the Common Market and EFTA," *J. Am. Stat. Assoc.* 65:1455–1459, Dec. 1970.

[2] Commission: European Coal and Steel Community, European Economic Community, European Atomic Energy Commission, *First General Report of the Activities of the Communities*, Brussels-Luxemburg, 1968.

[3] Department of State Bulletin, July 24, 1967.

[4] EFTA, *Agricultural Agreements between EFTA Countries*, Geneva, 1969.

[5] EFTA, *Convention Establishing the European Free Trade Association*, Geneva, 1963.

[6] Kemp, M. C., *A Contribution to the General Equilibrium Theory of Preferential Trading*, Amsterdam, North-Holland Publishing Co., 1969.

[7] Meade, J. E., *The Theory of International Economic Policy*, Vol. II, *Trade and Welfare*, London, Oxford University Press, 1955.

[8] Savage, I. Richard, and Karl W. Deutsch, "A Statistical Model of the Gross Analysis of Transaction Flows," *Econometrica* 28:551–572, July 1960.

[9] Taplin, Grant B., "Models of World Trade," *I.M.F. Staff Papers* 14:433–454, Nov. 1967.

[10] Vanek, Jaroslav, *General Equilibrium of International Discrimination*, Cambridge, Mass., Harvard University Press, 1965.

[11] Viner, Jacob, *The Customs Union Issue*, New York, Carnegie Endowment for International Peace, 1950.

Silage-Concentrate Substitution; Effects on Milk Production and Income Over Feed Cost in DHIA Herds*

D. H. Carley

Milk production response was determined with feed inputs and milk production converted to an estimated net energy basis. Differences in cow size, production, butterfat, and feed quality were taken into account. The data resulted in improved explanation of output variation and showed the importance of silage quality on silage-concentrate substitution.

SILAGE is rapidly increasing in importance as a source of nutrients for lactating dairy cows. Silage fed per cow annually increased 50 percent from 1965 to 1971 to a level of 12,900 pounds in Georgia DHIA herds. Larger herds, type of housing, labor limitations, and milking parlors encourage a feeding system in which a single ration can be group fed to all cows in the herd. Utilization of available forages in the form of silage supplemented with concentrates provides the opportunity to feed a total ration of a composition such that cows will be adequately fed under free choice feeding.

Research by McCullough [6] indicated that a program of testing silage to determine quality, computing grain and protein requirements to fit the silage quality, and feeding one combination of feeds free choice will increase and/or maintain milk production at a high level. Bath *et al.* [1] in a feeding trial found that cows fed rations based on least-cost concentrate mixes produced as well as cows fed commercial concentrate mixes, indicating that substitution among feed ingredients within appropriate constraints can decrease feed cost without affecting production.

Many DHIA herds are fed according to recommended nutrition levels with a least-cost combination of feedstuffs. By relating feed substitution ratios to feed price ratios and milk prices, it is possible to determine the optimum ration for profit maximization. Heady *et al.* [5], using data from experimentally controlled feeding conditions of small groups of dairy cows, determined milk production functions and substitution rates for concentrates and hay. Paris *et al.* [8] developed milk production functions using whole milk, fat content, skim milk, and 4 percent fat corrected milk as dependent variables to show differences in the functions as related to milk components.

Data from DHIA herds are used extensively throughout the United States for various purposes. However, analysts have expressed reservations with regard to the use of such data for purposes other than rather simplified analysis such as determination of averages. Reservations are related to accuracy of the data. Based on 1960–1964 data, Miller *et al.* [7] were doubtful that estimates of forage consumption and feed costs other than concentrates were worth the time and expense required to collect such data. However, DHIA data collection methods have been refined and are now more reliable for research purposes. In addition, silage has become a more important component of feed rations, and it should be analyzed as to production response, substitutability, and cost.

This study had the following objectives: (1) to develop a method of adjusting DHIA feed and milk production data to improve their usefulness in research and application; (2) to use the adjusted data to determine milk production response to several feedstuffs and the substitution rates in DHIA herds; and (3) to use the milk production functions and price ratios of feedstuffs to determine factors related to income over feed costs.

Data and Methods

Data were obtained from annual summaries of Georgia DHIA herds for test years completed in 1969 and 1970. Only those herds fed silage as one of the feeds were included in the analysis. Data included the annual herd averages per cow for concentrates, silage, and hay consumed, days of pasture, milk production, butterfat test, body weight, and total feed cost from 530 herd records.

Several problems were encountered in estimating production functions for milk from DHIA data. Feed requirement differences exist

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because of differences in the milk production level, because of differences in butterfat test and cow weights, and due to inherent capabilities of individual cows to utilize feeds. In addition, feeds (especially the forages) vary substantially in quality among herds.

The method used generally to adjust for butterfat differences in milk has been to convert or standardize milk for its butterfat content to a fat corrected milk (*FCM*) basis. Resulting milk production estimates can cause distortion of the original variables of milk and butterfat production. Adjusting for differences in the variables of cow weight, butterfat test, and milk production can be satisfied by converting these variables to a total feed requirement on an estimated net energy (*ENE*) basis.

DHIA feed data now include estimates of the estimated net energy (*ENE*) value of each feed on the basis of actual chemical analysis and/or estimates by the DHIA supervisor from guidelines in DHIA reference manuals [4]. Therefore it is possible to convert each feed to its *ENE* value.

For each herd used in this analysis, milk and butterfat production, cow weight, and feed inputs were converted to megacalories (*Mcal*) of net energy per year. Milk production, butterfat test, and cow weight were converted by the following formulas [2, 8]:

$$NE_p = 0.1321(M) + 4.964(F) \tag{1}$$

and

$$NE_m = 0.047(W)^{.75}(365) \tag{2}$$

$$TNE = NE_p + NE_m \tag{3}$$

where

NE_p = megacalories (*Mcal*) for milk production annually,
NE_m = megacalories (*Mcal*) for maintenance annually (365 days)
TNE = total megacalories (*Mcal*) annually,
M = milk per cow annually (pounds),
F = fat per cow annually (pounds),
W = weight of cow (pounds).

In the annual DHIA herd summaries, the percentage of *ENE* contributed by each of the four feed groups, concentrates, succulent forage (silages), dry forage (hay), and pasture is recorded. The *NE* contribution of each feed group in each herd was determined by the following formula:

$$NE_i = \frac{(G)(0.7)}{\%NE_g}(\%NE_i) \qquad i = 1, \cdots, M\text{: feeds} \tag{4}$$

where

NE_i = *Mcal* net energy for each feed group i annually,
G = pounds of concentrates,
$\%NE_g$ = percentage contribution of net energy from concentrates,
$\%NE_i$ = percentage contribution of net energy from each feed group i.

Since only the percentage contribution of *ENE* from each feed was available, the total *Mcal* of all feeds was determined by assigning concentrates a value of 0.7 *Mcal* per pound, multiplying the pounds of concentrates consumed by *NE* per pound, and dividing by the percentage contribution of *NE* from concentrates.

The model used to estimate the relationship of selected independent variables on estimated *Mcal* of *NE* for milk production and maintenance was of a quadratic form to allow for diminishing marginal rates of feed conversion.[1] The estimating equation was of the following form:

$$NE_p + NE_m = b_0 + b_1C + b_2C^2 + b_3S + b_4H + b_5PD \tag{5}$$

where

$NE_p + NE_m$ = milk production and maintenance in *Mcal*,
C = *Mcal* from concentrates,
S = *Mcal* from silage,
H = *Mcal* from hay,
PD = *Mcal* from pasture.

Income over feed cost per cow is the difference between the value of the product and total feed cost. Value of the product is dependent on level of production and price received for milk which varies by butterfat test. Feed cost is a function of the prices and quantities of each feed. Milk production is a function of the level of feeding. In order to estimate the effects of feeding level, feed substitution, and price ratios on income over feed cost per cow, the following equations were used:

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[1] The original model included squared terms and interaction terms. All the coefficients that did not differ from zero at the 5 percent level were eliminated from the model. Some coefficients eliminated had unexpected signs.

$$GI = [b_0 - NE_m + b_1C + b_2C^2 + b_3S + b_4H + b_5PD]D \tag{6}$$

and

$$FC = b_6 + b_7C + b_8C^2 + b_9S + b_{10}H + b_{11}PD \tag{7}$$

and

$$IOFC = GI - FC \tag{8}$$

where

GI = gross income from milk per cow (dollars),

FC = feed cost per cow (dollars),

$IOFC$ = income over feed cost per cow (dollars),

D = price of milk per *Mcal NE* (dollars per hundredweight of milk for given butterfat test divided by *Mcal* per hundredweight of milk for given butterfat test).

Equation (7) was used to estimate the effect of each feed input on total feed costs. An equation of this form may be used directly with equation (6) to evaluate marginal rates of substitution.

Results

Milk production averaged 11,730 pounds per cow. The average weight of the cows was 1,160 pounds. The *NE* in milk production and maintenance requirements averaged about 7,200 *Mcal* annually per cow (Table 1). Concentrates showed a highly significant non-linear relationship to output, that is, the output increased at a decreasing rate with additional quantities of concentrates. All other feeds showed highly significant linear positive relationships to output. The equation explained 51 percent of the variability in milk production and maintenance as measured in *Mcals NE*. An equation of the same form using actual pounds of milk and actual pounds of feed explained 36 percent of the variability in output [3]. Adjusting feeds and production to a common element, *ENE*, increased the percent of variability in milk production explained by the model.

An average of 3,405 *Mcal NE* were provided by concentrates, 2,379 *Mcal* from silage, 421 *Mcal* from hay, and 1,526 *Mcal* from pasture. The *Mcal NE* per hundredweight of concentrates was a constant of 70 used for all herds. The weighted average *Mcal NE* per 100 pounds of silage and hay were estimated to be 16.6 and 40, respectively. One day of pasture was estimated to furnish 4.8 *Mcal NE* per 1,000 pounds of cow weight. It was assumed in the analysis that all herds received balanced rations in terms of mineral requirements.

Table 1. Estimated multiple regression coefficients relating annual milk production per cow to feeds, 530 DHIA herds fed silage, Georgia, 1969 and 1970

Factor	Unit	Equation 5	
		Mean	Coefficient (b_i)
Total NE_p+NE_m	*Mcal NE*	7,200.57	—
Constant (b_0)	*Mcal NE*	—	3770.4420
Concentrates (C)	*Mcal NE*	3,404.67	0.6403[a]
C^2	*Mcal NE*	—	−0.00002976[b]
Silage (S)	*Mcal NE*	2,379.32	0.3626[a]
Hay (H)	*Mcal NE*	421.01	0.2985[a]
Pasture (PD)	*Mcal NE*	1,525.58	0.4149[a]
R^2	—	—	0.51

[a] $P<0.001$.
[b] $0.01<P<0.02$.

Equation (5) can be used in several ways to obtain additional information. The following adjustment makes the equation useful in predicting milk production at constant cow weights:

$$NE_p = b_0 - NE_m + b_1C + b_2C^2 + b_3S + b_4H + b_5PD. \tag{5.1}$$

The *Mcal* requirement for maintenance (NE_m) for each cow weight is subtracted from the constant (b_0). The equation can be used to predict milk production in terms of *Mcal* from various feeds and feeding levels. The relationships in Table 1 indicate that an increase of one *Mcal NE* of silage, hay, or pasture will result in an increase in milk production of *Mcal* NE_p equivalents of 0.36, 0.30, and 0.41, respectively.[2] At the weighted average of *Mcal NE*

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[2] To convert NE_p to pounds of milk per pound of a given feed,

$$\text{Milk} = \frac{NE_p - 4.964\,F}{0.1321}; \; F = (M)(\text{butterfat percent}, B),$$

therefore

$$M = \left[\frac{NE_p}{0.1321}\right] \div [(37.5776)(B) + 1]$$

and for any feed f, NE_p per unit of feed = (NE_p)(*Mcal* per unit),

$$\text{so} \quad M = \left[\frac{(NE_p)(Mcal_f)}{0.1321}\right] + [(37.5776)(B) + 1].$$

Table 2. Estimated quantities of concentrate and silage for producing specified levels and butterfat percentages of annual milk production per cow, by cow weight[a]

Concentrates		Cow weight					
		800 lbs.			1,200 lbs.		
lbs.	*Mcal NE*	Pounds of 3.5 percent butterfat milk					
		9,000	12,000	15,000	9,000	12,000	15,000
		Mcal NE needed from silage					
2,000	1,400	59	2,640	5,222[b]	2,575	5,156	7,738
4,000	2,800	0	651	3,232	585	3,167	5,748
6,000	4,200	0	0	1,564	0	1,499	4,080
8,000	5,600	0	0	218	0	153	2,734
Concentrates		Pounds of 4.5 percent butterfat milk					
lbs.	*Mcal NE*	9,000	12,000	15,000	9,000	12,000	15,000
		Mcal NE needed from silage					
2,000	1,400	1,151	4,096	7,042	3,667	6,612	9,558
4,000	2,800	0	2,107	5,052	1,677	4,623	7,568
6,000	4,200	0	439	3,384	96	2,955	5,900
8,000	5,600	0	0	2,038	0	1,609	4,554

[a] Estimated from coefficients in Table 1, hay and pasture included at mean levels in all combinations.

[b] Pounds of silage required for 5,000 *Mcal NE* and above would be beyond the capacity of the cow unless it was very high quality.

of each feed and 3.5 percent butterfat milk, milk production increased 0.20 pound per pound of silage, 0.39 pound per pound of hay, and 6.4 pounds per day of pasture.

Changes in milk production from the increased concentrates depend on the level of the concentrate feeding. At a level of 5,000 pounds (3,500 *Mcal*÷0.7) annually of concentrates, milk production increased at a rate of 0.98 pounds per pound increase in concentrate.

The coefficients from equation (5) were used to predict various feed combinations or substitutions possible in obtaining specified levels of milk production. It was possible to vary the quality of the roughages in the estimating procedure and to determine to some extent not only the effect of substitution between feed groups but substitutions within a feed group, as well. Substitution of two feeds, holding the others constant at their mean values, was used in the estimating procedure.

Concentrate-silage quantities for two cow weights, three levels of milk production, and two butterfat tests are shown in Table 2. For each level of concentrate feeding, each additional increase of 100 pounds in cow weight requires an additional 3,789 pounds of silage annually (629 *Mcals NE*). At each level of concentrate feeding, each additional 100 pounds of milk required an additional 518 pounds of silage (86 *Mcals NE*÷0.166) for 3.5 percent milk and an additional 590 pounds (98 *Mcal NE*) for 4.5 percent milk.

Increasing the *NE* from concentrates decreases the *NE* requirement from silage at a decreasing rate. For instance, increasing the *NE* from concentrate from 1,400 to 2,800 *Mcals* reduces *NE* required from silage by 1,990 *Mcals*. However, increasing *NE* from concentrate from 4,200 to 5,600 reduces *NE* requirements from silage by 1,346 *Mcals*. The pounds of silage required can be estimated by dividing the *NE* required by the *NE* in silage. For example, a 4,000 *NE* silage requirement would require 26,670 pounds of silage containing 15 *Mcal NE* per hundredweight or 19,050 pounds of silage containing 21 *Mcal NE* per hundredweight.

Marginal rates of substitution of concentrate for silage were estimated from the derivative of silage with respect to concentrate. The equation

$$\frac{dS}{dC} = 1.7659 - 0.000164C$$

shows the marginal rate of substitution of concentrate for silage in terms of *Mcal NE*. Marginal rates of substitution are the same for a given concentrate input regardless of cow weight, level of milk production, and butterfat test since the relationship has only a linear term for silage [equation (5)]. As the level of concentrate is increased, each additional unit of concentrate replaces less silage due to the nonlinear relationship of concentrate on milk production (Table 3). Also, the substitution rates of concentrate for two quality levels of silage show the advantage of feeding a higher quality silage in terms of concentrate-silage requirements.

With silage as the primary feed supplemented by concentrates, primary consideration is the effect of the additional silage and/or higher quality silage on income over feed cost. The economic question involved is whether the value of the incremental output (milk production) equals or exceeds the value of the incremental input (feed ration) used to obtain the increase in production. To estimate the effect of feeding level and feed cost on income over feed cost per cow, the results from equation (5) with a price factor added were used to estimate the value of product [equation (6)]. Equation (7) shows the feed cost per cow as a function of various feeding rates. Thus, equation (8), income over feed cost, becomes an accounting equation of value of product minus feed cost. The following equation shows the complete relationship:

$$
\begin{aligned}
(8)\qquad IOFC = {} & [(3770.44 - NE_m)(D) \\
& + 0.6403(C)(D) \\
& - 0.00002976(C^2)(D) \\
& + 0.3626(S)(D) + 0.2985(H)(D) \\
& + 0.4149(PD)(D)] \\
& - [+ 18.6081 + 0.0589(C) \\
& - 0.000002(C^2) + 0.0261(S) \\
& + 0.0376(H) + 0.0157(PD)].
\end{aligned}
$$

With the use of partial derivatives of income over feed cost with respect to the various feeds, the points where marginal revenue from the various feeds are equal to marginal cost of the feed were determined. Partial derivatives for each feed were:

Concentrates

$$
\begin{aligned}
(8.1)\qquad \frac{d(IOFC)}{d(C)} = {} & - 0.0589 + 0.000004C \\
& + 0.6403D \\
& - 0.00005952(C)D,
\end{aligned}
$$

Table 3. Estimated marginal rates of substitution between concentrates and silage

Concentrates		Marginal rates of substitution		
		Mcal NE[a]	Silage containing[b]	
lbs.	*Mcal NE*		15 *Mcal NE*/100 lbs.	21 *Mcal*/100 lbs.
			pounds	
2,000	1,400	1.5363	10.2	7.3
4,000	2,800	1.3067	8.7	6.2
6,000	4,200	1.0771	7.2	5.1
8,000	5,600	0.8745	5.8	4.2

[a] *Mcal NE* of silage replaced by one additional *Mcal NE* from concentrate.

[b] Pounds of silage replaced by one additional pound of concentrate for two quality levels of silage.

Silage

$$(8.2)\qquad \frac{d(IOFC)}{d(S)} = 0.3626D - 0.0261,$$

Hay

$$(8.3)\qquad \frac{d(IOFC)}{d(H)} = 0.2985D - 0.0376,$$

Pasture

$$(8.4)\qquad \frac{d(IOFC)}{d(PD)} = 0.4149D - 0.0157.$$

At given price levels of milk, feeding additional quantities of concentrates will decrease income over feed cost to a point where the marginal cost of the additional concentrate fed will equal the marginal return of the additional milk produced.

Income over feed cost must also be large enough to cover other costs associated with producing milk. Therefore, milk price minus other costs is the net remaining to cover feed costs. If concentrates are fed at a level of 5,000 pounds annually or 3,500 *Mcal NE*, the net price of milk to cover feed costs could be as low as $3.24 per hundredweight before the cost of the concentrates added would be equal to the net value of the milk added.

Concentrate prices were about 30 percent higher in early 1973 compared to the 1969–70 study period. If concentrates continue to be fed in the same proportion to other feeds, the effect of the higher concentrate costs would be to increase the net price of milk necessary to cover concentrate costs to $4.20 per hundredweight; the point where the cost of concentrates added would be equal to the net value of the milk sold.

The partial derivatives for silage, hay, and pasture are constants. As long as the production coefficient times the milk price is greater than the cost coefficient for a given feed, marginal returns to silage, hay, and pasture will increase in a fixed proportion with each additional unit fed.

For silage, the net milk price could be as low as \$2.25 per hundredweight before the cost of silage added would be equal to the value of the milk added. Or, with 3.5 percent butterfat milk at a net price of \$5.00 per hundredweight, silage cost would need to be greater than \$0.0581 per *Mcal NE* or about \$20 per ton before the cost of feeding additional silage exceeds the value of milk. For hay, marginal cost would equal marginal returns with a net milk price of \$3.93 per hundredweight of 3.5 percent milk. At a net milk price of \$5.00 per hundredweight, hay would need to cost more than \$0.0478 per *Mcal NE* or about \$38 per ton before the cost exceeds the value of the milk.

Concluding Remarks

Milk production and feed inputs were adjusted to an estimated net energy (*ENE*) basis. This allowed for differences in energy requirements due to cow weight, milk production, and butterfat test and for differences in energy available from various feedstuffs relative to type and quality. Equating marginal rates of substitution of concentrate and silage to their price ratios shows that least cost combinations are at points where silage should be fed free choice with concentrates playing a supplementary role.

Based on the production coefficient for various feeds fed Georgia DHIA herds and current feed and milk prices, income over feed cost could be increased with increased feeding rates of concentrates or forages. The analysis showed the value of feeding increased quantities of silage provided the inherited ability of the cow to produce and/or rumen capacity has not been reached. The quantity of good quality silage required is considerably less than poor quality silage to produce a given level of milk.

References

[1] BATH, D. L., S. E. BISHOP, G. A. HUTTON, JR., J. C. OLIVER, AND G. W. DEAN, "Computer-Formulated Least-Cost Concentrate Mixes for Dairy Cows," *J. Dairy Sci.* 51:1616–1619, Oct. 1968.

[2] CARDON, B. P., "A Feeding Program for Milking Dairy Cows—NE-Milk," *Feedstuffs* 42:54–56, Nov. 1970.

[3] CARLEY, D. H., *Analysis of Feeding Programs Used in DHIA Herds in Georgia*, Georgia Agr. Exp. Sta. Res. Bull. 120, Nov. 1972.

[4] *Dairymen's DHIA Reference Manual for the Southern Region*, North Carolina Agr. Ext. Serv., S. Regional Dairy Ext. Pub. No. 1, Sept. 1968.

[5] HEADY, EARL O., JOHN A. SCHNITTKER, NORMAN L. JACOBSON, AND SOLOMON BLOOM, *Milk Production Functions, Hay/Grain Substitution Rates and Economic Optimum in Dairy Cow Rations*, Iowa Agr. Exp. Sta. Res. Bull. 444, Oct. 1956.

[6] MCCULLOUGH, MARSHALL E., *Optimum Feeding of Dairy Animals*, Athens, Georgia, Univ. of Georgia Press, 1969.

[7] MILLER, R. H., B. T. MCDANIEL, AND M. E. CREEGAN, "Dairy Herd Improvement Association Yearly Herd Averages. I. Sources of Variation and Relations Among Measurements," *J. Dairy Sci.* 51:1659–1666, Oct. 1968.

[8] PARIS, Q., F. MOLOSSINI, A. M. PILLA, AND A. ROMITA, "A Note on Milk Production Functions," *Am. J. Agr. Econ.* 52:594–598, Nov. 1970.

Consumer Demand for Meat in Canada*

P. Tryfos and N. Tryphonopoulos

An application of Zellner's [13] two-stage procedure is illustrated in the estimation of the parameters of a system of linear, contemporaneously related demand functions for beef, veal, pork, lamb, and chicken meat in Canada, based on annual data for the period 1950 to 1970.

Two studies published in the last ten years have estimated demand functions for meat in Canada. Yeh [12] estimated demand functions for beef and pork, using annual data for the period 1929 to 1958. More recently, Kulshreshtha and Wilson [3] estimated the demand function for beef only as a part of an econometric model of the Canadian beef sector, using annual data for the period 1949–1969.[1]

In the present study, the demand functions for beef, veal, pork, lamb, and chicken meat are simultaneously estimated on the basis of annual data for the period 1954 to 1970. The per capita consumption of beef, veal, pork, domestic lamb, and chicken meat are the dependent variables; deflated retail prices (or prices indexes) and per capita deflated personal disposable income are the principal explanatory variables. Zellner's method of estimating "seemingly unrelated regression equations" [13] is employed because of the contemporaneous correlation among the dependent variables. To examine the extent and degree of substitution among different kinds of meat, a statistical test (the simultaneous equations analogue of the familiar F-test) is used to reduce the demand equations by removing insignificant price and income variables. The implied price and income elasticities are calculated. A comparison of actual and predicted values shows that a large proportion of the variation in the demand of meat in Canada is explained by the model.

Demand Equations

Economic theory suggests that the quantity of a given meat product demanded at the retail level depends on the price of that meat product, the prices of other meat products, and income. A negative correlation can be expected between the quantity demanded and the own price of the meat product; the correlation between quantity demanded and the price of substitute meats is expected to be positive.

In the absence of any *a priori* information concerning the degree of substitution among different meat products, it is reasonable to begin with a system of demand functions in which all meat prices and income appear as explanatory variables in all equations:[2]

$$(1.1)\quad QB;\, PB, PV, PL, PP, PC, PDI$$

$$(1.2)\quad QV;\, PB, PV, PL, PP, PC, PDI$$

$$(1.3)\quad QLD;\, PB, PV, PL, PP, PC, PDI, QLI$$

$$(1.4)\quad QP;\, PB, PV, PL, PP, PC, PDI$$

$$(1.5)\quad QC;\, PB, PV, PL, PP, PC, PDI, QT.$$

Variables

The variables are defined as follows.

Dependent variables

QB = per capita disappearance of beef, lbs. [5]
QV = per capita disappearance of veal, lbs. [5]
QLD = per capita disappearance of domestic mutton and lamb, lbs. [5]
QP = per capita disappearance of pork, lbs. [5]
QC = per capita disappearance of chicken meat, lbs. [6].

Independent variables

PB = consumer price index of beef, deflated,[3] (1961 = 100) [7]

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[1] Similar U. S. studies can be found in references [1, 2, 4, 9].

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[2] A semicolon is the usual shorthand notation for "a linear function of." An error term is implicitly associated with each equation.

[3] The consumer price index for Canada, all items, 1961 = 100, [7], was used to deflate the price series for PB, PV, PL, PP, and PDI.

PV = consumer price index[4] of veal, deflated, (1961 = 100) [7]
PL = consumer price index[5] of lamb, deflated, (1961 = 100) [7]
PP = consumer price index of pork, deflated, (1961 = 100) [7]
PC = retail price of chicken, deflated, cents per pound [7]
QLI = per capita disappearance of imported mutton and lamb, pounds [5]
QT = per capita consumption of turkey meat, pounds [6]
PDI = per capita personal disposable income, deflated, hundreds of dollars [8].

In addition to meat prices and income, two other variables are included to capture product-specific substitution effects: equation (1.3) includes the per capita consumption of imported lamb,[6] and equation (1.5) includes the per capita consumption of turkey meat as explanatory variables; quantities rather than prices were used because retail prices were not available for imported lamb and turkey meat over the entire period.

Ordinarily, demand functions are simultaneously estimated with supply functions. A particular feature of the Canadian livestock industry will explain the absence of any supply considerations from the model. Because of the proximity and the relatively low tariffs between the two countries, livestock prices in Canada are closely related to U. S. prices. Because of its market size, the U. S. is the dominant partner in this trade relationship. If, temporarily, the interaction of Canadian demand and supply for livestock leads to a Canadian price that is significantly different from the U. S. price, opportunities for arbitrage will give rise to exports or imports, as a result of which livestock prices (adjusted for exchange rate differences) will be equalized. Canadian wholesale prices, in turn, follow livestock prices, and retail prices are closely related to wholesale prices. Thus, Canadian retail prices are determined to a large extent by an exogenous variable—U. S. livestock prices. This feature of the Canadian livestock sector can be exploited, since it allows separate and accurate estimates of demand and supply functions.[7]

When the error terms of a system of equations are contemporaneously correlated and the set of explanatory variables is not the same in each equation, classical least-squares (OLS) is not an efficient method of estimation. For correlated systems of linear equations in reduced form, Zellner's [13] two-stage estimation procedure (Z2SLS) is appropriate. In this procedure an estimate is first made of the error terms' variances and covariances, based on the residuals derived from an equation-by-equation application of OLS;[8] in the second stage, these estimates are used to construct the Aitken estimator of the regression coefficients in all equations.

To preserve space, the Z2SLS estimates of equations (1.1)–(1.5) are not presented here. Of the 37 estimated coefficients, eight "other" price coefficients had the wrong sign. An obvious explanation for these inconsistent price effects is that each explanatory variable does not affect all dependent variables. This implies that a certain subset of the 37 coefficients is equal to zero; estimation error and the occasionally high correlation between certain explanatory variables could have produced the observed inconsistent signs.

There is little guidance in the economic literature as to which explanatory variables may be omitted from which equations. Does the price of veal, for instance, affect the con-

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[4] Index is based on the average retail price for Canada of veal, loin chop.

[5] Index is based on the average retail price for Canada of lamb, leg roast.

[6] Certain special features of the lamb sector in Canada should be noted. For the past 20 years, imports of lamb, mainly from Australia and New Zealand, have been increasing steadily. Since 1961, the per capita consumption of imported lamb has been greater than the per capita consumption of domestic lamb; in 1970 the per capita consumption of imported lamb was 3.27 pounds, while that of domestic lamb was only 0.23 pounds. The major part of these imports consists of frozen lamb, which is sold at retail prices sufficiently low to overcome the consumers' traditional preference for fresh meat. Since the retail price of frozen lamb is not available, it is not possible to estimate the demand for frozen (imported) lamb.

[7] The determinants of Canadian livestock, wholesale, and retail meat prices, and Canada's trade position with respect to the U. S. are examined in [10]; Canadian livestock supply and inventory functions are estimated in [11].

[8] There was no evidence of serial correlation in the OLS residuals of each equation. Estimates of the correlation coefficients among the error terms are as follows:

	QB	QV	QLD	QP	QC
QB	1.00	.62	.32	−.26	−.41
QV		1.00	.82	.16	−.63
QLD			1.00	−.03	−.65
QP				1.00	.26
QC					1.00

Table 1. Demand equations, regression results[a]

Dep. Var.	Explanatory Variables									U-Statistic	Equation Number
	PB	*PV*	*PL*	*PP*	*PC*	*QLI*	*QT*	*PDI*	Constant		
QB	−0.392 (−4.30)		0.039 (0.38)	0.118 (1.28)				4.094 (9.17)	35.927 (2.04)	0.010	(2.1)
QV		−0.096 (−3.95)	0.035 (1.31)		0.039 (1.32)			0.210 (1.66)	8.449 (2.07)	0.030	(2.2)
QLD			−0.024 (−2.19)		0.004 (0.30)	−0.130 (−1.26)		−0.259 (−4.93)	7.926 (5.56)	0.056	(2.3)
QP	0.138 (2.59)	0.317 (4.57)	0.137 (2.55)	−0.519 (−10.91)				−0.013 (−0.05)	42.652 (4.67)	0.007	(2.4)
QC		0.001 (0.01)			−0.045 (−0.63)		−0.498 (1.44)	1.783 (4.83)	−5.103 (−0.67)	0.019	(2.5)

[a] Estimates of the regression coefficients are given in the first line; "*t*-values" are shown in parentheses.

sumption of beef? Is there any evidence that beef is a substitute for lamb—at least in the range of observed prices? Are the prices of veal and lamb helpful in explaining the variation in pork consumption? Both statistical and economic considerations are important in determining which variables may not be dropped.

Several hypotheses were considered and, in each case, the parameters of the reduced equations were examined. Of these alternatives, the model which is consistent and retains the maximum number of explanatory variables is given below:

(2.1) $QB; PB, \quad PL, PP, \quad PDI$

(2.2) $QV; \quad PV, PL, \quad PC, PDI$

(2.3) $QLD; \quad PL, \quad PC, PDI, QLI$

(2.4) $QP; PB, PV, PL, PP, \quad PDI$

(2.5) $QC; \quad PV, \quad PC, PDI, QT.$

It will be noted that the above system of equations is the system (1.1)–(1.5) under the hypothesis that, simultaneously, the parameters of the missing variables are equal to zero. The test statistic for this hypothesis, as Zellner [13] has shown, has approximately the F-distribution, with 11 and 48 degrees of freedom in this case. At the customary 5 percent level, the critical F-value is approximately equal to 2.00; the test statistic in this case is equal to 0.75, and the hypothesis may be accepted. Thus, the system (2.1)–(2.5) is statistically consistent with the system (1.1)–(1.5).

The Z2SLS estimates of equations (2.1)–(2.5) are shown in Table 1.[9] All price coefficients have the expected signs; all own price coefficients are negative; all "other" price coefficients are positive. The coefficient of the per capita consumption of imported lamb is negative, as was expected. The coefficient of turkey consumption in equation (2.5) is positive, suggesting that chicken and turkey meat are not substitutes in consumers' budgets. Income coefficients are positive for beef, veal, and chicken, and negative for domestic lamb.

An essential criterion for the performance of an econometric model is its success in simulating the time series of the dependent variables. The fit of the estimated equations is good, as can be inferred from the values of the U-statistic,[10] and from Figure 1, in which actual and ex-

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[9] Equations (2.1)–(2.5) were also estimated by OLS. The estimates of the regression coefficients were different but of the same order of magnitude; for example, the OLS estimates of the own price effects were −.406 in (2.1), −.130 in (2.2), −.016 in (2.3), −.502 in (2.4), and −.059 in (2.6). Estimates of the standard deviations of the regression coefficients, however, were without exception lower for Z2SLS; on the average the OLS estimates were 14.3 percent higher, ranging from 3.4 percent to 37.5 percent. This increase in precision is, of course, a valuable advantage of Z2SLS whenever "*t*-values" are used for inferences concerning the regression parameters.

[10] A measure of predictive accuracy is Theil's U-statistic, defined as follows:

$$U = \sqrt{\Sigma(P_i - A_i)^2}/(\sqrt{\Sigma P_i^2} + \sqrt{\Sigma A_i^2})$$

where A are the actual and P the explained values. The value of this statistic is in the range 0, 1. $U=0$ indicates perfect prediction; $U=1$ indicates a zero or negative proportionality between actual and predicted values.

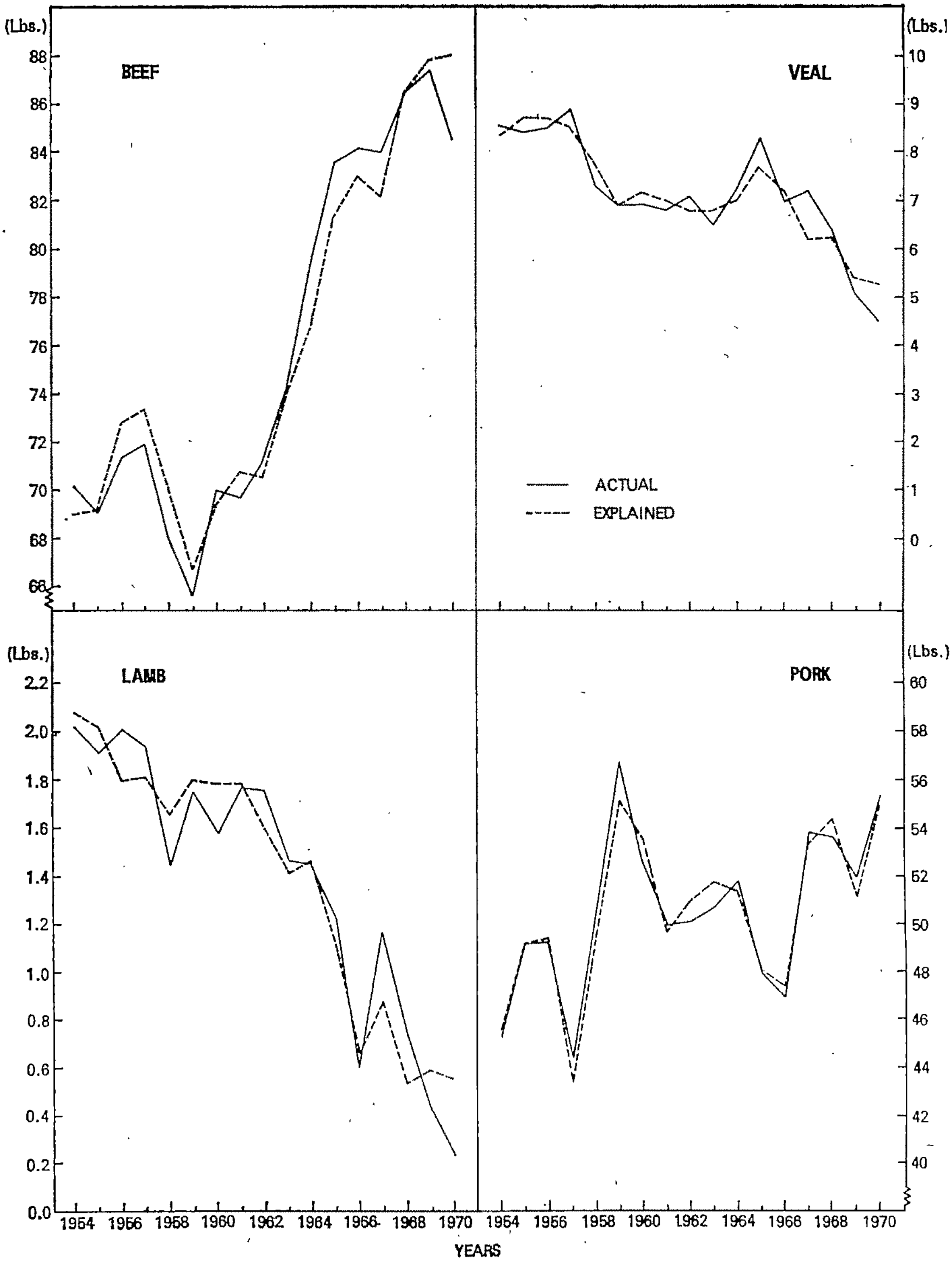

Figure 1. Per capita disappearance of meat, actual and explained

Table 2 Price and income elasticities[a]

Per Capita Consumption of	Prices of Beef (*PB*)	Veal (*PV*)	Lamb (*PL*)	Pork (*PP*)	Chicken (*PC*)	Personal Disp. Income (*PDI*)
Beef (*QB*)	−.521		.053	.159		.835
Veal (*QV*)		−1.400	.507		.259	.455
Dom. Lamb (*QLD*)			−1.801		.138	−2.909
Pork (*QP*)	.276	.654	.281	−1.049		− .004
Chicken (*QC*)		.004			−.087	1.129

[a] Point elasticities calculated from equations (2.1)–(2.5) at the means of the variables.

plained meat consumption are compared. Explained values are obtained by using the actual values of the explanatory variables and the coefficient estimates of equations (2.1)–(2.5).

Price and Income Elasticities

The estimated own price elasticity of beef in Table 2 is lower than estimates obtained by Yeh [12], (−.644) for the period 1947–58, and by Kulshreshtha and Wilson [3], (−.801) for the period 1949–69, but it is still of the same order of magnitude. The estimate of the income elasticity of beef is closer to the estimate in [3], (1.044), than to Yeh's (.393). In the case of the demand for pork, the only other available estimates are Yeh's [12] for the period 1947–58; he estimates the own price elasticity, the cross price elasticity with respect to the price of beef, and the income elasticity, respectively, as —.651, —.216 (*sic*), and −1.258. There are no other results available with which to compare the remaining estimates of Table 2.

The high income elasticity of chicken meat is rather surprising, as is the high negative income elasticity of domestic lamb; both may be attributable, however, to a change in tastes over time that is highly correlated with income. For all red meats, consumption is sensitive to own price changes. Consumption of beef, veal, and domestic lamb is not affected by changes in the prices of other meats. Consumption of pork, on the other hand, is sensitive to changes in the prices of beef, veal, and lamb. This suggests that substitution effects may not be entirely symmetric. For example, a rise in the price of pork may not lead to an increase in the consumption of beef, but only to a decrease in pork consumption; on the other hand, an increase in beef prices will result in an increase in pork consumption and a decrease in beef consumption.[11]

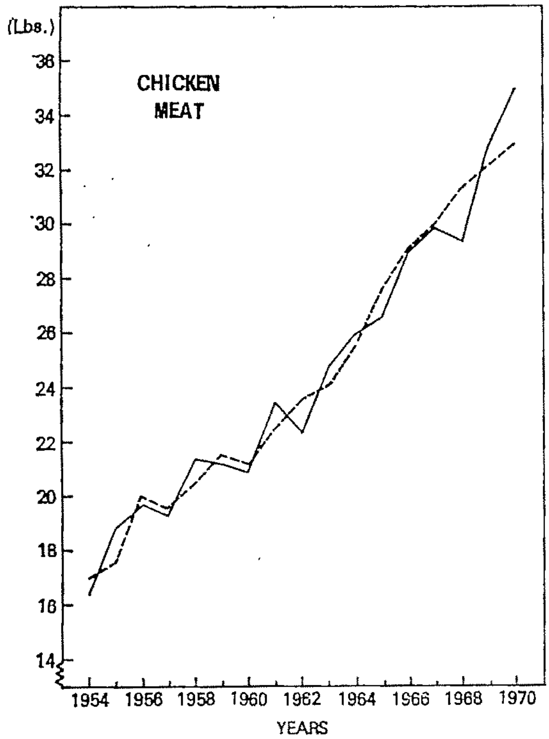

Figure 1, continued

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[11] Similar findings for the U. S. are reported in Trierweiler and Hassler [9, p. 12].

References

[1] CROM, R. J., "Computer Models of Price and Output Determination in the Livestock Meat Economy," unpublished Ph.D. thesis, Iowa State University, 1964.

[2] FULLER, W. A., AND G. W. LADD, "A Dynamic Quarterly Model of the Beef and Pork Economy," *J. Farm Econ.* 43:797–812, Nov. 1961.

[3] KULSHRESHTHA, S. N., AND A. G. WILSON, "An Open Econometric Model of the Canadian Beef Cattle Sec-

tor," *Am. J. Agr. Econ.* 54:84–91, Feb. 1972.

[4] LANGEMEIER, L., AND R. G. THOMPSON, "Demand, Supply and Price Relationships for the Beef Sector, Post-World War II Period," *Am. J. Agr. Econ.* 49: 169–183, Feb. 1967.

[5] Statistics Canada, *Livestock and Animal Products Statistics*, Cat. No. 23-203.

[6] Statistics Canada, *Production of Poultry and Eggs*, Cat. No. 23-202.

[7] Statistics Canada, *Prices and Price Indexes*, Cat. No. 62-002.

[8] Statistics Canada, *Canadian Statistical Review*, Cat. No. 11-003.

[9] TRIERWEILER, J. E., AND J. B. HASSLER, "Measuring Efficiency in the Beef-Pork Sector by Price Analysis," *Agr. Econ. Res.* 23:11–17, Jan. 1971.

[10] TRYFOS, P., "The Determinants of Prices and Employment in the Canadian Meat Industry," Working Paper, Faculty of Administrative Studies, York University, Downsview, Ontario, Nov. 1972.

[11] ———, "A Note on Livestock Supply and Canadian Supply Functions of Livestock and Meat," Working Paper, Faculty of Administrative Studies, York University, Downsview, Ontario, March 1973.

[12] YEH, M. H., "Consumer Demand for Beef and Pork in Canada," *Can. J. Agr. Econ.* 9:68–78, 1961.

[13] ZELLNER, A., "An Efficient Method for Estimating Seemingly Unrelated Equations and Tests for Aggregation Bias," *J. Am. Stat. Assoc.* 57:348–368, June 1962.

Supply of Storage Theory and Commodity Equilibrium Prices with Stochastic Production

STANLEY R. PLISKA

When future production is a random variable, the equilibrium price for a commodity will be that which yields the maximum expected discounted utility of the consumption quantities and the supply of storage. The equilibrium consumption schedule is obtained with the dynamic programming techniques of inventory theory.

THE starting point for this investigation of commodity prices is supply of storage theory. Briefly (see, e.g., [2, 3, 7, 8]), at any given time t the difference between the expected spot price at some future time $t+h$ (the futures price) and the spot price is some function of the current level of inventory. If the function $f(I)$ denotes this relationship, then $f(I)$ is thought to be a continuous, increasing function assuming both negative and positive values for non-negative levels of inventory I. Thus if I is large (such as just after a harvest), the futures price would exceed the spot price, whereas if I is small (such as just before a harvest), the spot price would exceed the futures price.

The problem with the supply of storage theory is that it explains price differences but not absolute price levels. In [5] Samuelson incorporates (deterministic) knowledge of future commodity production, assumes current consumption is a (deterministic) function of only the current price, and shows that the schedule of equilibrium prices (or, equivalently, the schedule of equilibrium consumption rates) up to some horizon time maximizes a certain utility function of the consumers, subject to the constraint that the inventory level remain non-negative. His utility function is a special case of the one considered here, with the difference being stochastic rather than deterministic production. However, the economic interpretation of both models is the same. If the theoretical equilibrium consumption schedule is maintained, then the consumers will be ambivalent between storing inventories themselves or letting someone else do it. Thus if the spot price were to rise above the equilibrium value, then competition among the sellers would serve to drive prices down. On the other hand, if the spot price were to fall below the equilibrium value, then consumers would enter the market place to purchase additional quantities for storage and future consumption, thereby increasing prices. Therefore speculative arbitrage serves to maintain this consumption schedule.

In [6] Samuelson allows future commodity production to be a series of random variables, but he drops the notion of the supply of storage function. By using dynamic programming concepts, he shows that the equilibrium consumption schedule maximizes the expected utility of the consumers, but his model does not allow for negative carrying charges.

The purpose of this paper is to apply supply of storage theory to the notion of stochastic commodity production. Using the basic utility function (specified below) of [5], the equilibrium consumption schedule will be that which yields the maximum expected discounted utility. In the case of discrete time and either a finite or an infinite horizon, the optimal consumption schedule is obtained with dynamic programming techniques as in inventory theory. The basic problem is formulated in the next section. The finite time horizon case where the capacity of the inventory system is unbounded is considered. Then is discussed the infinite time horizon case where the inventory system capacity is now finite.

Discrete-Time Consumption Schedule

The problem formulated here is to determine the optimal consumption schedule for the time periods $n=1, 2, \cdots, N$, where N is the (possibly infinite) time horizon. Consider the sequence $D_1, D_2, \cdots$ of independently distributed, non-negative random variables with D_n, the production in period n, specified by the distribution function $\Phi_n(\cdot)$. If C_n and I_n are respectively the nth period consumption and inventory levels, then the utility of consuming C_n and storing I_n-C_n is $U_n(C_n)-F(I_n-C_n)$, where $U_n(\cdot)$ is a concave non-decreasing function whose derivative is the consumers' demand curve for period n and $F(\cdot)$ is a convex function whose derivative is the one-period supply

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of storage function f (for ease of exposition, the units of cost and utility are interchangeable). Thus the problem to be solved is the following:

$$\text{maximize } E \sum_{n=1}^{N} \alpha^{n-1}[U_n(C_n) - F(I_n - C_n)]$$

$$\text{subject to: } I_{n+1} = S\Lambda(I_n + D_n - C_n), \quad n = 1, \cdots, N-1$$

$$0 \leq C_n \leq I_n, \quad n = 1, \cdots, N,$$

where E is the expectation operator, α is a discount factor ($0<\alpha\leq 1$), the (possibly infinite) number S represents the maximal capacity of the inventory system (assume excess production is destroyed at no cost to the consumer), $(x\Lambda y) = \min \{x, y\}$, and I_1 is specified. Note that this formulation is a generalization of both Samuelson's deterministic one [5] and his stochastic one [6].

Let $V_n(I)$, a suitable real-valued function on $[0, S]$, denote the maximum expected discounted utility at the beginning of period n given that the inventory then is I. Thus, for example, $V_1(I_1)$ is the value of the objective function in the above optimization problem. Let T_n denote the optimal return operator defined by

$$T_nV(I) = \max_{0\leq C\leq I} \left\{U_n(C) - F(I - C) + \alpha \int V(S\Lambda[I + D - C])d\Phi_n(D)\right\}.$$

Thus dynamic programming theory can be used to solve the above optimization problem, because if the maximum expected discounted utility $V_{n+1}(\cdot)$ for period $n+1$ is known and T_nV_{n+1} exists, then $V_n = T_nV_{n+1}$. In general some additional assumptions are necessary to guarantee the existence of a sequence of functions satisfying $V_n = T_nV_{n+1}$. One may also be interested in the range of the operator T_n and, of course, the optimal consumption schedules. These matters are considered for various discrete time inventory models in the following two sections.

The Finite Time Horizon Case

For this class of discrete-time inventory models, assume the inventory capacity $S = \infty$ and the time horizon $N < \infty$. In addition, assume that the terminal expected discounted utility $V_{N+1}(\cdot)$ is concave and, for ease of exposition, $V_{N+1}(\cdot)$, $U_n(\cdot)$, and $F(\cdot)$ are twice continuously differentiable. One further assumption is required, namely:

$$(1) \quad \begin{aligned} &U_n'(0) > \alpha U_{n+1}'(0) - F'(0), \quad n = 1, 2, \cdots, N-1, \\ &U_N'(0) > \alpha \int V_{N+1}'(D)d\Phi_N(D) - F'(0). \end{aligned}$$

Assumption (1) serves to ensure that some of the inventory will always be consumed during the current period by making it more profitable to sell some inventory now than in succeeding periods. This assumption can apparently be regarded as a constraint on the utility functions in the immediate proximity of the origin because, for example, given any $\epsilon>0$, any strictly concave $U_n(C)$ can be modified on $[0, \epsilon)$ so as to satisfy Assumption (1) and maintain strict concavity. Note that if $U_n'(0) = U_{n+1}'(0)$ and $F'(0) < 0$, then α must be less than 1.

Let $C_n(I)$ denote an optimal consumption level in period n corresponding to inventory I at the beginning of period n. Then the optimal consumption schedule is characterized by Theorem 1.

Theorem 1

For the problem with finite horizon N and concave terminal expected discounted cost $V_{N+1}(I)$, suppose Assumption (1) is true. Then there exists a sequence of positive numbers $\{\bar{I}_n\}$, where

$$\bar{I}_n = \max \left\{I \mid U_n'(I) + F'(0) - \alpha \int V_{n+1}'(D)d\Phi_n(D) \geq 0\right\},$$

such that the optimal consumption schedule is of the following form.

In period n, if the beginning inventory $I \leq \bar{I}_n$, then $C_n(I) = I$ and $V_n'(I) = U_n'(I)$, while if $\bar{I}_n < I$, then $\bar{I}_n \leq C_n(I) \leq I$, where $C_n(I)$ is the smallest root of

$$(2) \quad U_n'(C) + F'(I - C) - \alpha \int V_{n+1}'(I + D - C)d\Phi_n(D) = 0,$$

and $V_n'(I) = U_n'(C_n[I]) \geq U_n'(I)$. Moreover, $C_n(I)$ is a continuous, differentiable function,

$$0 \le \frac{dC_n(I)}{dI} \le 1,$$

and $V_n(I)$ is concave and twice continuously differentiable.

Proof

This proof (by induction) is similar in spirit to those for standard dynamic inventory problems (see, for example, [1, Ch. 9]). For period N, the decreasing function $U_N'(I)+F'(0)-\alpha\int V_{N+1}(D)d\Phi_N(D)$ is positive for $I=0$, so $\bar{I}_N>0$ exists, although perhaps $\bar{I}_N=\infty$.

If $I\le\bar{I}_N$, then for all $C\le I$

$$\begin{aligned} &U_N'(C)+F'(I-C)\\ &\qquad -\alpha\int V_{N+1}'(I+D-C)d\Phi_N(D)\\ &\ge U_N'(\bar{I}_n)+F'(0)\\ &\qquad -\alpha\int V_{N+1}'(D)d\Phi_N(D)\ge 0 \end{aligned}$$

in which case $C_N(I)=I$ is optimal,

$$\begin{aligned} V_N(I) &= U_N(I)-F(0)\\ &\qquad +\alpha\int V_{N+1}(D)d\Phi_N(D), \end{aligned}$$

and $V_N'(I)=U_N'(I)$.

If $\bar{I}_N<I<\infty$, then (2) has a solution $C_N(I)$ with $\bar{I}_N\le C_N(I)\le I$ because the left hand side of (2) is a continuous decreasing function of C with

$$\begin{aligned} &U_N'(\bar{I}_N)+F'(I-\bar{I}_N)\\ &\qquad -\alpha\int V_{N+1}'(I+D-\bar{I}_N)d\Phi_N(D)\\ &\ge U_N'(\bar{I}_N)+F'(0)\\ &\qquad -\alpha\int V_{N+1}'(D)d\Phi_N(D)=0\\ &\ge U_N'(I)+F'(0)\\ &\qquad -\alpha\int V_{N+1}'(D)d\Phi_N(D). \end{aligned}$$

The function $C_N(I)$ is continuously differentiable by the implicit function theorem, so differentiating (2) with respect to I, it is concluded that $0\le C_N'(I)\le 1$.

Thus if $\bar{I}_N<I$,

$$\begin{aligned} V_N(I)&=U_N(C_N[I])-F(I-C_N[I])\\ &\qquad +\alpha\int V_{N+1}(I+D-C_N[I])d\Phi_N(D). \end{aligned}$$

Differentiating this equation with respect to I obtains $V_N'(I)=U_N'(C_N[I])\ge U_N'(I)$ from (2), $C_N(I)\le I$, and $U_N'(\cdot)$ non-increasing. Thus $V_N'(I)=U_N'(C_N[I])$ for all I, so $V_N'(I)=U_N''(C_N[I])C_N'(I)\le 0$ and $V_N(I)$ is concave and twice continuously differentiable.

To complete the proof, it suffices to show that

$$U_{N-1}'(0)+F'(0)-\alpha\int V_N'(D)d\Phi_{N-1}(D)>0;$$

this follows from Assumption (1) and the fact that

$$\begin{aligned} -\alpha\int V_N'(D)d\Phi_{N-1}(D) &\ge -\alpha V_N'(0)\\ &= -\alpha U_N'(0). \blacksquare \end{aligned}$$

It should be remarked that if $V_{N+1}(I)$ and $U_n'(I)$ ($n=1, 2, \cdots, N$) are strictly concave, then for each n, equation (2) has a unique solution, $0<dC_n(I)/dI<1$ and $V_n'(I)>U_n'(I)$ for all $I>\bar{I}_n$, and $V_n(I)$ is strictly concave. Since the nth period equilibrium price is $U_n'(C_n[I])$, this will be positive for all appropriate I if $U_n'(I)>0$.

The results of Theorem 1 are strongly related to the supply of storage theory. Notice that $V_n'(I)$ equals the price for period n with initial inventory level I. Equation (1) says (assuming the discount factor is approximately 1) the difference between the expected price for next period and the spot price is equal to the supply of storage function F' evaluated for the amount of inventory after consumption. Conversely, the supply of storage theory implies the numbers in the sequence $\{\bar{I}_n\}$ are very small in practical cases. If $I\le\bar{I}_n$, then one can write

$$\alpha\int U_{n+1}'(C_{n+1}[D])d\Phi_n(D)-U_n'(I)\le F'(0)$$

which (assuming the discount factor is approximately 1) is compatible with supply of storage theory only if I is approximately zero.

If certain additional knowledge is known about a finite horizon problem, one can better characterize the optimal consumption schedule. Given the distribution functions $\Phi_i(D)$ and $\Phi_j(D)$, then Φ_i is said to be stochastically smaller than Φ_j, written $\Phi_i\subset\Phi_j$, if $\Phi_i(D)\ge\Phi_j(D)$ for all D. Thus, for example, the expected production level would be higher with Φ_j than with

Φ_i. A basic property of stochastically ordered probability distributions is that if $v(D)$ is a non-decreasing function, then $\Phi_i \subset \Phi_j$ implies $\int v(D)d\Phi_i(D) \leq \int v(D)d\Phi_j(D)$.

Theorem 2

For the problem with finite horizon N, suppose $U_1(I)=U_2(I)= \cdots U_N(I)=V_{N+1}(I) \equiv U(I)$ is a concave function with $(1-\alpha)U'(0) > -F'(0)$, and suppose $\Phi_1 \subset \Phi_2 \subset \cdots \Phi_N$. Then Theorem 1 applies and for each period n $(n=1, 2, \cdots, N-1)$, $V_n'(I) \geq V_{n+1}'(I)$, $\bar{I}_n \leq \bar{I}_{n+1}$, and $C_n(I) \leq C_{n+1}(I)$.

Proof

First, $U'(0) \geq \int V_{N+1}'(D)d\Phi_N(D)$ so Assumption (1) holds and Theorem 1 applies. The remainder of the proof is by induction; if one lets $C_{N+1}(I)=I$ and $\bar{I}_{N+1}=\infty$, then the theorem is true for period N. Now assume the theorem is true for periods $n+1, n+2, \cdots, N$.

By definition of $\bar{I}_n$ and since $\Phi_n \subset \Phi_{n+1}$,

$$0 = U'(\bar{I}_n) + F'(0) - \alpha \int V_{n+1}'(D)d\Phi_n(D)$$

$$\leq U'(\bar{I}_n) + F'(0) - \alpha \int V_{n+1}'(D)d\Phi_{n+1}(D)$$

$$\leq U'(\bar{I}_n) + F'(0) - \alpha \int V_{n+2}'(D)d\Phi_{n+1}(D),$$

so by definition of $\bar{I}_{n+1}$, $\bar{I}_n \leq \bar{I}_{n+1}$. Similarly, if $I > \bar{I}_{n+1}$, by the definitions of $C_n(I)$ and $C_{n+1}(I)$, then $C_n(I) \leq C_{n+1}(I)$. Finally, by concavity of $U(I)$,

$$V_n'(I)=U'(C_n[I]) \geq U'(C_{n+1}[I])=V_{n+1}'(I). \blacksquare$$

The stochastic ordering hypothesis in Theorem 2 means generally that commodity production levels are increasing in time. The conclusion of Theorem 2 corresponds to one's intuition: if the consumers' demand curve is constant in time, then for identical inventory levels in any two periods, the consumption level will be higher and the price will be lower for the later period.

The Infinite Time Horizon Case

To characterize the optimal, discrete-time consumption schedule as the horizon increases to infinity, it is convenient to assume the inventory system has a finite capacity S. As with the finite horizon, infinite capacity inventory systems, assume $U_n(C)$ and $F(I-C)$ have finite continuous derivatives on $[0, S]$, but now one must allow the expected discounted utility for a period to have a discontinuous derivative. If one assumes $U_N(C)$ and $V_{N+1}(I)$ are non-decreasing on $[0, S]$, then one can show that $V_N(I)$, $C_N(I)$, and $I-C_N(I)$ are, too. The following theorem, a counterpart to Theorem 1, will be used for the infinite horizon situation.

Theorem 3

For the finite capacity inventory system problem with finite horizon N, suppose $U_1(C), \cdots, U_N(C)$, and $V_{N+1}(I)$ are concave non-decreasing functions on $[0, S]$ and assume Assumption (1) holds. Then the conclusions of Theorem 1 hold for this problem, and the maximum expected discounted utility in each period is a non-decreasing function on $[0, S]$.

Proof

Generalizing the reasoning in the proof of Theorem 1, let $\tilde{V}(I)=V_{N+1}(I \Lambda S)$ be defined for all $I < \infty$ so that for $I \leq S$, then

$$V_N(I) = \max_{0 \leq C \leq I} \Big\{ U_N(C) - F(I-C) + \alpha \int_0^\infty \tilde{V}(I+D-C)d\Phi_N(D) \Big\};$$

Thus the proof of Theorem 1 can be followed if one allows for the fact that $\tilde{V}'(I)$ is discontinuous. The first complication arises in the calculation of $C_N(I)$ for $I > \bar{I}_N$. It is not difficult to see that

$$C_N(I) = \sup \Big\{ C \,\Big|\, U_N'(C) + F'(I-C) - \alpha \int_0^\infty \tilde{V}'(I+D-C)d\Phi_N(D) \geq 0 \Big\}, \tag{2}$$

in which case $C_N(I)$ is a continuous, non-decreasing function. Moreover, if the inequality in (2) is strict at I, then $dC_N(I)/dI=1$. The only other complication arises in the computation of $V_N'(I)$ for $I > \bar{I}_N$. If the inequality in (2) is strict at I, then by the above $V_N'(I)=U_N'(C_N[I])$; otherwise, Theorem 1 can be followed to show the same result. Thus the conclusions of Theorem 1 hold for period N; in particular, $V_N'(I) \geq U_N'(I) \geq 0$ for $I \leq S$, $V_N'(I)$ is continuous on $[0, S]$, and the proof is completed by induction. $\blacksquare$

In the case of an infinite horizon, assume the production probability distributions and consumer demand curves are periodic with period M, that is, $\Phi_N=\Phi_{n+M}=\cdots$ and $U_n(C)=U_{n+M}(C)=\cdots$ for $n=1, 2, \cdots, M$. The M successive periods terminating in a period which is a multiple of M can be thought of as a "commodity year." If one defines the optimal return operator T_n in the obvious way and assumes the discount factor $\alpha<1$, then by Theorem 3 and the Contraction Mapping Theorem one obtains Theorem 4.

Theorem 4

In the infinite horizon case with periodic production and consumer demand, suppose $\alpha<1$, Assumption (1) holds, and $U_1(C), \cdots, U_M(C)$ are concave, non-decreasing functions on $[0, S]$. Then the maximum expected discounted utility V_n for the nth period of a commodity year is the unique concave non-decreasing function that is a fixed point of the optimal return operator $T_n \cdots T_M T_1 \cdots T_{n-1}$. Moreover, V_n can be obtained by the method of successive approximations, and the optimal consumption schedule is characterized by the conclusions in Theorem 1.

It is convenient at this point to reconcile the foregoing with the expectations about commodity price behavior. Suppose a commodity is seasonal and the commodity year is comprised of N periods with production occurring only at the end of the Nth period. Thus the inventory will be at a maximum during the first period and by (2) there will be three cases. If the first period's inventory is approximately "normal," then $F'(I-C_1[I])$ will be positive and the prices will rise during the commodity year until some period n (when $F'[I-C_n(I)]$ becomes sufficiently negative), and then the prices will decline during the remainder of the year. In particular, the expected price at the beginning of the next commodity year will be less than the price at the end of the current year. Alternatively, if the first period's inventory is sufficiently higher than "normal," then prices will increase through the beginning of the following year ($F'[I-C_n(I)]$ never becomes sufficiently negative). Finally, if the first period's initial inventory is sufficiently less than "normal," the prices will decline during the entire year.

Next consider the effects of a change in expectations about future production. Suppose anticipations about production in period N change from Φ to Ψ with $\Phi\subset\Psi$ (implying an increase in expected production) while anticipations for other periods remain unchanged. Arguing as in the proof of Theorem 2, it can be shown that the optimal consumption levels for period N will increase, implying a decrease in the derivative of the Nth period maximum expected discounted utility. This, in turn, implies an increase in optimal consumption levels for period $N-1$, so by induction one concludes the optimal consumption level will increase during the current period, and the spot price will immediately decrease. In addition, $F'(I-C_1[I])$ will decrease, so by equation (2) the difference between the futures price and the spot price will decrease. Similarly, a change in period N from Φ to Ψ with $\Phi\supset\Psi$ will increase the spot price and basis. In either case, the more distant the period for which a change ensues, the less will be the immediate effect.

Concluding Remarks

The results indicate that the concept of stochastic commodity production can be combined with the supply of storage theory to yield a satisfactory model of commodity price levels and differences. Theorem 1 shows that the theoretical price differences are compatible with the supply of storage theory in the finite time horizon, infinite inventory capacity case. The same conclusion can be drawn from Theorems 3 and 4 which are counterparts to Theorem 1 in the finite horizon, finite capacity and infinite horizon, finite capacity cases, respectively. The concept of periodic production and consumption was introduced in Theorem 4, and the theoretical prices were found to be compatible with the way prices actually fluctuate seasonally. The concept of stochastic ordering was introduced in Theorem 2 and later in order to confirm various expectations about the way prices react to changing production levels; the theoretical results corresponded with the author's intuition.

In formulating the operator T_n, it was decided to express the one-period storage cost as $F(I-C)$ rather than $F(I)$ because if this is thought to be a cost to the consumers rather than to the inventory operators, then it could be argued that one of its components is the transportation cost associated with the acquisition of amount C. If the time period is small enough, then the one-period consumption level will be small relative to the inventory level, and the two formulations should yield nearly the same results.

The dynamic programming formulations of this paper can be generalized to allow non-independent and non-periodic random variables (cf. Hinderer [4]). Another topic for future research is the question of whether the supply of storage theory can be dropped without making the model unable to account for negative carrying charges.

References

[1] ARROW, K. J., S. KARLIN, AND H. SCARF, *Mathematical Theory of Inventory and Production*, Stanford, California, Stanford University Press, 1958.

[2] BRENNAN, M. J., "The Supply of Storage," *Am. Econ. Rev.* 48:50–72, March 1948.

[3] COOTNER, P. H., "Speculation and Hedging," *Food Res. Inst. Studies* 7 (Supplement): 65–106, 1967.

[4] HINDERER, K., *Foundations of Non-stationary Dynamic Programming with Discrete Time Parameter*, Lecture Notes in Operations Research and Mathematical Systems, eds. M. Beckmann and H. P. Kunzi, Vol. 33, Berlin, Springer, 1970.

[5] SAMUELSON, P. A., "Intertemporal Price Equilibrium: A Prologue to the Theory of Speculation," in *Collected Scientific Papers*, ed. Joseph E. Stiglitz, Cambridge, MIT Press, 1966, pp. 946–984.

[6] ———, "Stochastic Speculative Price," *Proceedings of the National Academy of Sciences* 68:335–337, Feb. 1971.

[7] WORKING, H., "Theory of the Inverse Carrying Charge in Futures Markets," *J. Farm Econ.* 30:1–28, Feb. 1948.

[8] ———, "The Theory of the Price of Storage," *Am. Econ. Rev.* 39:1254–1262, Dec. 1949.

Sufficient Conditions for Aggregation of Linear Programming Models*

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Three sets of sufficient conditions for exact aggregation of linear programming models are discussed. They provide a relaxation of the proportionality and dimensionality conditions among elements of the micro problems required by R. H. Day's specification. For correct aggregation it is not necessary to classify firms according to "homogeneity" criteria.

ECONOMISTS in general, and agricultural economists in particular, have widely demonstrated their relentless interest for using linear programming models to analyze the economic process of a sector, a region, or an entire economy [6, 8, 15]. The literature on the subject has assumed further momentum in recent years with the application of such models to developing economies [1, 7, 9]. Proper utilization of such models rests on several assumptions regarding the specification of the objective function, the admissible technology, the existing limitations of commodities and, last but not least, the level of aggregation of the various economic micro units.

The purpose of this paper is to present some reflections and results about this last aspect as it relates to linear programming methods. Surprisingly, the literature on the problem of aggregation in linear programming is rather limited regardless of whether it deals with the methodological [2, 3, 4, 11, 12, 13] or with the empirical [5] aspects. Briefly stated, the empirical aspects of the problem refer to the development of a computationally feasible procedure which minimizes the aggregation bias, whatever its definition. The methodological ones do not immediately concern the feasibility of the computations, but rather the conditions under which it is possible to achieve aggregation with zero bias. This analysis focuses on the methodological aspects of aggregation. The focus is motivated by the fact that only after achieving awareness of the theoretical requirements implied by different formulations of the aggregation problem is it possible to develop computationally feasible procedures of sufficient generality and validity.

Historical Perspective

In 1963 R. H. Day [2] formulated an aggregation problem for solutions of linear programming models and proposed a set of conditions sufficient to achieve aggregation with zero bias. Specifically, if the linear programming models are interpreted in the context of K producing units, Day's conditions require (a) that the matrix of technical coefficients in every firm be identical to the matrix of the aggregate problem; (b) that the vectors of resources and of net revenues of every firm be proportional to the corresponding aggregate vectors; and, finally, (c) that the sum of the product of weights of the firm objective functions and of the proportionality factors for the net revenue vectors be equal to one.

Subsequently, T. A. Miller [13] and J. E. Lee [11] have argued that Day's strict proportionality requirement is unduly restrictive. Their result is based on an application of sensitivity analysis to Day's formulation of the aggregation problem. Finally, Marenco [12] has shown the redundancy of Day's condition (c) above.

The above papers are representative of the methodological discussion of the aggregation problem in linear programming. Actually, Day, while recognizing Marenco's comments [4], has denied any substance to those of Miller and Lee [3], reiterating the soundness of his original formulation and conclusions: "As a conjecture, I would suggest that sufficient conditions for aggregation less binding than those presented in this paper, will be difficult to obtain" [2, p. 812]. His suggestions for further advances in this area lie with the study of mathematical and behavioral analysis of "management leadership" and the testing of aggregate models of the representative firm [3, p. 673].

It is demonstrated below that the state of the

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discussion about aggregation in linear programming is unsatisfactory. Indeed, not only do Day's specifications represent the most restrictive set of sufficient conditions conceivable, but unless a statistical framework is advanced, it is practically impossible to find any two firms which satisfy such conditions. Obviously, sufficient conditions are of interest because they may indicate an easy test for LP aggregation; but on the other hand they are of greater interest if they realistically admit the existence of empirical cases which satisfy the specified requirements. It is the judgment of the authors that it is not possible to find empirical cases which fit Day's sufficient conditions. Therefore, it is important to investigate whether it is possible to find other less binding formulations and to analyze what they imply in terms of empirical usefulness. The quest for conditions less binding comes also from Sengupta and Fox [15] when they write, "It is still an open question how to define a process of valid aggregation (e.g., without aggregation bias) when condition (2.77a) (i.e., all firms have identical input-output coefficient matrices) is not satisfied" [15, p. 72].

Sufficient Conditions for Exact Aggregation

In general the aggregation problem arises when an "expanded" dual pair of micro linear programming problems, such as

$$\begin{aligned} &\max z = c'x \\ (1) \qquad &Ax \leq b \\ &x \geq 0 \end{aligned}$$

$$\begin{aligned} &\min r = b'y \\ (2) \qquad &y \geq o, \\ &A'y \geq c, \end{aligned}$$

has to be collapsed into an "aggregate" macro dual pair of programs

$$\begin{aligned} &\max z_o = c_o'x_o \\ (3) \qquad &A_o x_o \leq b_o \\ &x_o \geq 0 \end{aligned}$$

$$\begin{aligned} &\min r_o = b_o'y_o \\ (4) \qquad &y_o \geq 0 \\ &A_o'y_o \geq c_o \end{aligned}$$

of smaller dimensions than (1) and (2) respectively. The matrix of A of (1) and (2) is, in general, a block diagonal matrix, i.e.,

$$A = \begin{bmatrix} A_1 & \cdots & 0 \\ \cdot & A_2 & \cdot \\ \cdot & \cdot & \cdot \;\; \cdot \\ 0 & \cdots & A_K \end{bmatrix}$$

where the submatrices $A_1, A_2, \cdots, A_K$ may be thought of as representing the technical coefficient matrices of K firms. Similarly, the vectors c and b may be represented in form of K partitions, i.e., $c' = (c_1', c_2', \cdots, c_K')$, $b' = (b_1', b_2', \cdots, b_K')$, which denote respectively the vectors of net revenues and resources of the K firms. Each kth submatrix A_k, $k = 1, \cdots, K$, is of dimensions $(M_k \times N_k)$, while the matrix A is of dimensions $(M \times N)$. The matrix A_0 is the technical coefficient matrix of the aggregate problem with dimensions $(H \times L)$, $H < M$, and $L < N$. The vectors c_0 and b_0 are respectively the vectors of net revenue and resources of the aggregate problem.

Following Day, aggregation is exact (or perfect, or without loss of information) when the following relations are satisfied:

$$(5.1) \quad \bar{x}_o - G'\bar{x} = 0$$

$$(5.2) \quad \bar{y}_o - P'\bar{y} = 0$$

$$(5.3) \quad c_o'\bar{x}_o - c'\bar{x} = 0 \quad \text{or, alternatively,}$$

$$\bar{y}_o'b_o - \bar{y}'b = 0,$$

where $(\bar{x}, \bar{y})$ and $(\bar{x}_0, \bar{y}_0)$ are optimal solution vectors to the expanded and aggregate dual problems respectively. Matrices G and P are of dimensions $(N \times L)$ and $(M \times H)$, respectively, and represent aggregation operators. They contain the partitions and the weights with which the expanded dual solutions should be aggregated. The elements of the G matrix are usually specified to be either 1 or 0, but for the general formulation specified in this paper this restriction will not be imposed. Furthermore, it is only required that optimal solutions (and not all feasible solutions) of the dual pairs of micro and macro problems satisfy relations (5). In fact, for the purpose of this paper, it is sufficient to find conditions of aggregation valid only for *some* optimal solutions of the micro and macro pairs of problems.

To grasp fully the implications of exact aggregation, notice that the number n of different production activities considered by the group of K firms as candidates for a production plan is, in general, greater than the number of activities considered by any single firm, i.e.,

$n \geq \max_k N_k$. Therefore, the aggregate problem must consider a number of production activities at least equal to n, and, furthermore, all n activities of the group must be represented in the L activities of the aggregate problems $(H \times L)$; hence, $L \geq n$. On the other hand, since a linear programming solution can contain no more activities at nonzero level than the number of constraints, it is necessary that the number H of aggregate constraints be also greater or equal to n.

The quest for conditions of exact aggregation may be stated as follows: how can sufficient conditions be specified, which are both "not too restrictive" and "operational in a meaningful way." The term "not too restrictive" is here taken to mean that some real life situations may, in principle, fit the conditions. Here, "operational in a meaningful way" indicates a computational procedure that does not involve the inverse of the matrix A. Day's conditions were judged too restrictive because they require either the equality or the proportionality among technical and economic elements of the K firms, and equal dimensionality of all K firms' problems. The objective of what follows is to relax these restrictions one at a time. This will be done within the context of three separate cases.

Case 1. The following formulation represents a set of sufficient conditions for exact aggregation which do not require either equality or proportionality among the elements of the K firms. They do require, however, equal dimensionality of all the firms' problems. These conditions are

$$b = S\Gamma_H b_o \tag{6.1}$$

$$c = R\Gamma_L c_o \tag{6.2}$$

$$A = KSI_K \otimes A_o R \tag{6.3}$$

$$\frac{1}{K} P'S^{-1}\Gamma_H = I_H \tag{6.4}$$

$$\frac{1}{K} G'R^{-1}\Gamma_L = I_L. \tag{6.5}$$

S and R are square matrices of order M and N respectively. Furthermore they are both diagonal with positive coefficients. The matrices Γ_H and Γ_L are of dimensions $(M \times H)$ and $(N \times L)$ and are composed respectively of K identity submatrices stacked on top of one another of order H and L. The matrices I_H, I_L, and I_K are identity matrices of order H, L, and K respectively. Finally, K is a positive scalar representing the number of firm problems to be aggregated, and $\otimes$ denotes the Kronecker product.

Note that the role of the diagonal matrices S and R is to relax any proportionality or equality requirements. The fact that their diagonal elements are strictly positive implies that all the firm's problems have the same dimensionality. It is now possible to state the main result of *Case 1*: if the conditions specified in (6) hold and there exist optimal solutions to the aggregate problems, $(\bar{x}_o, \bar{y}_o)$, the aggregation problem as defined in (5) possesses an exact solution for some optimal programs of the expanded problem.

To prove this result, it is sufficient to exhibit one such pair of optimal solutions for the expanded problem. Such a pair is the following:

$$\bar{x} = \frac{1}{K} R^{-1}\Gamma_L \bar{x}_o \tag{7.1}$$

$$\bar{y} = \frac{1}{K} S^{-1}\Gamma_H \bar{y}_o. \tag{7.2}$$

The solutions $\bar{x}$, $\bar{y}$ must be checked against the feasibility and the optimality criteria. First of all, given the specifications of K, R, S, Γ_L, Γ_H, and the optimality of $(\bar{x}_o, \bar{y}_o)$, $\bar{x}$ and $\bar{y}$ are nonnegative. They are also feasible since

$$\begin{aligned} A\bar{x} &= KSI_K \otimes A_o R\bar{x} \\ &= SI_K \otimes A_o \Gamma_L \bar{x}_o \leq S\Gamma_H b_o = b \end{aligned} \tag{8.1}$$

and

$$\begin{aligned} \bar{y}'A &= \bar{y}'SI_K \otimes A_o RK \\ &= \bar{y}_o'\Gamma_H' I_K \otimes A_o R \geq c_o'\Gamma_L R = c'. \end{aligned} \tag{8.2}$$

Optimality of $\bar{x}$, $\bar{y}$ follows directly from the following relations

$$\begin{aligned} c'\bar{x} &= c_o'\Gamma_L' RR^{-1}\Gamma_L \bar{x}_o \frac{1}{K} \\ &= c_0'\Gamma_L'\Gamma_L \bar{x}_o \frac{1}{K} = c_o'\bar{x}_o \end{aligned} \tag{9.1}$$

$$\begin{aligned} b'\bar{y} &= b_o'\Gamma_H' SS^{-1}\Gamma_H \bar{y}_o \frac{1}{K} \\ &= b_0'\Gamma_H'\Gamma_H \bar{y}_o \frac{1}{K} = b_o'\bar{y}_o \end{aligned} \tag{9.2}$$

since by hypothesis $c_0'\bar{x}_0 = b_0'\bar{y}_0$. Relations (9.1) and (9.2) verify also the condition for exact aggregation of the K firms' objective functions

Table 1

	Firm 1			Firm 2			Aggregate		
		A_1			A_2			A_o	
Technical coefficient matrix	24/5	9/2	81/20	8/5	1/3	3/5	4	2	3
	2/3	15/4	3	2	5/2	6	1	3	4
		c_1			c_2			c_o	
Net revenue vectors	2	3	1/2	6	2	1	3	12/5	2/3
		b_1			b_2			b_o	
Resource vectors	9	2	--	1	2	--	10	4	--
		$\bar{x}_1$			$\bar{x}_2$			$\bar{x}_o$	
Primal optimal solutions	33/20	6/25	0	11/20	9/25	0	11/5	3/5	0
		$\bar{y}_1$			$\bar{y}_2$			$\bar{y}_o$	
Dual optimal solutions	11/30	9/25	--	33/10	9/25	--	33/50	9/25	--
		B_1^{-1}			B_2^{-1}			B_o^{-1}	
Inverse of the optimal basis	1/4	-3/10	—	3/4	-1/10	—	3/10	-1/5	—
	-2/45	8/25	—	-3/5	12/25	—	-1/10	2/5	—
		S_1			S_2				
S matrices	9/10	0	—	1/10	0	—			
	0	1/2	—	0	1/2	—			
		R_1			R_2				
R matrices	2/3	0	0	2	0	0			
	0	5/4	0	0	5/6	0			
	0	0	3/4	0	0	3/2			
		G_1			G_2				
G matrix	1	0	0	1	0	0			
	0	1	0	0	1	0			
	0	0	1	0	0	1			
		P_1			P_2				
P matrix	1	0	—	4/45	0	—			
	0	1/3	—	0	2/3	—			

specified by (5.3). To verify the other conditions of exact aggregation, it is only necessary to multiply (7.1) and (7.2) by G' and P' respectively and apply (6.3) and (6.4); that is,

$$(10.1) \qquad G'\bar{x} = \frac{1}{K} G'R^{-1}\Gamma_L\bar{x}_o = \bar{x}_o$$

$$(10.2) \qquad P'\bar{y} = \frac{1}{K} P'S^{-1}\Gamma_H\bar{y}_o = \bar{y}_o.$$

The numerical example presented in Table 1 illustrates the conditions for this first case. There are two firms denoted by indexes 1 and 2, whose LP models must be collapsed into an aggregated model denoted by index o. Note that the net revenue vectors c_o, c_1, c_2, the resource vectors b_o, b_1, b_2, and the technical coefficient matrices A_o, A_1, A_2, are neither equal nor proportional among each other. The dimensionality of the three problems, however, is the same. To save space, the matrices S and R are given in the form of their partions S_1, S_2 and R_1, R_2 respectively. In this example S and R are square diagonal matrices of order 4 and 6 respectively and, therefore, S_1, S_2, R_1, R_2 are also diagonal. It is easily verified that the conditions of exact aggregation specified in (5) are satisfied exactly. It is also seen that the optimal solutions of the firm's problems can be obtained equivalently either directly (by solving the respective LP problems) or by using relations (7.1) and (7.2), after solving only the aggregate problem. Note that the aggregation conditions for this case require that the activities' indexes entering the optimal firm and aggregate solutions are the same.[1]

Case 2. As a special case derived from *Case 1*, it is possible to obtain a slightly more general version of the sufficient conditions originally formulated by Day. Suppose that the matrices G and P are specialized to obtain

$$(5'.1) \quad \sum_{k=1}^{K} \hat{x}_k = \hat{x}_o$$

$$(5'.2) \quad \sum_{k=1}^{K} \alpha_k \hat{y}_k = \hat{y}_o, \ \alpha_k \geq 0, \ k = 1, \cdots, K$$

$$(5'.3) \quad \sum_{k=1}^{K} c_k \hat{x}_k = c_o' \hat{x}_o.$$

The vectors, $\hat{x}_k$, $\hat{y}_k$, c_k, b_k, $k=1, \cdots, K$ are of the same dimensions for all K, and α_k is a scalar. Suppose that each of the K diagonal submatrices forming the matrix S specializes to a scalar matrix $\lambda_k I$, with $\lambda_k > 0$. Then it is possible to state the following set of sufficient conditions which guarantee exact aggregation as specified in (5′):

$$(11.1) \quad b_k = \mu_k b_o, \ \mu_k > 0, \ k = 1, \cdots, K$$

$$(11.2) \quad c_k = \lambda_k c_o, \ \lambda_k > 0, \ k = 1, \cdots, K$$

$$(11.3) \quad A_k = \gamma_k A_o K, \ \gamma_k > 0, \ k = 1, \cdots, K$$

$$(11.4) \quad \frac{\gamma_k}{\mu_k \lambda_k} = 1, \ k = 1, \cdots, K$$

$$(11.5) \quad \sum_{k=1}^{K} \frac{1}{\lambda_k K} = 1$$

$$(11.6) \quad \sum_{k=1}^{K} \frac{\alpha_k}{K \mu_k} = 1$$

where μ_k, λ_k, γ_k, K are positive scalars.[2] In this setting, if an optimal pair of dual solutions exists for each firm's problems, aggregate optimal solutions exist which satisfy relation (5′).

To prove the assertion, let

$$(12.1) \quad \hat{x}_o = K \lambda_k \hat{x}_k$$

$$(12.2) \quad \hat{y}_o = K \mu_k \hat{y}_k \qquad k = 1, \cdots, K.$$

It is claimed here that $\hat{x}_o$ and $\hat{y}_o$ as defined in (12) are optimal solutions to the aggregate problem and satisfy conditions (5′). First, note that $\hat{x}_o$ and $\hat{y}_o$ are nonnegative since $K>0$, $\lambda_k>0$, $\mu_k>0$, $\hat{x}_k$, $\hat{y}_k$ are optimal for all k's. Furthermore, they are feasible since

$$(13.1) \quad \begin{aligned} A_o \hat{x}_o &= A_k \hat{x}_k \frac{K}{K} \frac{\lambda_k}{\gamma_k} \leq \frac{\lambda_k}{\gamma_k} b_k \\ &= \frac{\mu_k \lambda_k}{\gamma_k} b_o = b_o \end{aligned}$$

$$(13.2) \quad \begin{aligned} \hat{y}_o' A_o &= \hat{y}_k' A_k \frac{K}{K} \frac{\mu_k}{\gamma_k} \geq \frac{\mu_k}{\gamma_k} c_k' \\ &= \frac{\mu_k \lambda_k}{\gamma_k} c_o' = c_o'. \end{aligned}$$

To prove that $\hat{x}_o$ and $\hat{y}_o$ are optimal, it suffices to note that

$$(14.1) \quad K c_k' \hat{x}_k = c_o' \hat{x}_o$$

$$(14.2) \quad K \hat{y}_k' b_k = \hat{y}_o' b_o, \qquad k = 1, \cdots, K$$

together with $c_k'\hat{x}_k = \hat{y}_k' b_k$, the optimality criterion for each kth firm. Exact aggregation of the objective function is shown by summing (14) over k, i.e.,

$$(15.1) \quad \sum_k c_k' \hat{x}_k = \sum_k \frac{1}{K} c_o' \hat{x}_o = c_o' \hat{x}_o$$

$$(15.2) \quad \sum_k \hat{y}_k' b_k = \sum_k \frac{1}{K} \hat{y}_o' b_o = \hat{y}_o' b_o.$$

Finally, for the aggregation of the optimal solutions, by summing (12) over k and applying (11.5) and (11.6), one obtains

$$(16.1) \quad \sum_k \hat{x}_k = \sum_k \frac{1}{K \lambda_k} \hat{x}_o = \hat{x}_o$$

and

$$(16.2) \quad \sum_k \alpha_k \hat{y}_k = \sum_k \frac{\alpha_k}{K \mu_k} \hat{y}_o = \hat{y}_o.$$

Case 3. It remains to relax the restriction, required by both cases 1 and 2, that all the K firm problems have the same dimensionality. This was done by the authors [14] in rather general terms as a direct generalization of the condi-

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[1] The sufficient conditions presented here are derived as a special case of more general conditions which may be found in [14]. For similar specification see [10].

[2] Day's formulation specifies that $A_k = A_o$ for all k. Thus,

$$\mu_k \lambda_k = 1, \quad \sum_{k=1}^{K} \mu_k = 1 \quad \text{and} \quad \sum_{k=1}^{K} \alpha_k \lambda_k = 1.$$

tions specified in *Case 1*. There seems to be, however, more than one way by which such a relaxation may be obtained. The following specification is one alternative.

Suppose that for a group of K "homogeneous" firms it is possible to know *a priori* the activities that will enter the optimal basis in each firm. With this information, it is an easy matter to specify the matrix G. Furthermore, suppose that if a firm operates an activity at a positive level, it will operate it at a level $(1/L_j)\bar{x}_{oj}$, L_j being the number of firms that will operate the jth activity at positive levels. Note that G, although a rectangular matrix, can be assumed to be of full rank without loss of generality. Then, if there exists a primal optimal solution $\bar{x}_o$ to the aggregate problem, the condition (5.1) for the exact aggregation of the k firm's primal solution is satisfied. In fact let $\bar{x}=G^+\bar{x}_o$ where G^+ is the Moore-Penrose generalized inverse of G. By virtue of the full rank property of the matrix G, this generalized inverse is $G^+=G(G'G)^{-1}$. Therefore, multiplying $\bar{x}=G^+\bar{x}_o$ by G', one obtains $G'\bar{x}=G'G^+\bar{x}_o=G'G(G'G)^{-1}\bar{x}_o=\bar{x}_o$ which is the condition (5.1).

Furthermore, suppose that the matrix P of condition (5.2) is specified as $P=\bar{P}\Lambda$, where P, similarly to G, is a full rank matrix and Λ is a diagonal matrix with positive coefficients on the diagonal and of dimensions $(H\times H)$, H being the number of macro constraints in A_o. The magnitude of the scalars on the diagonal may be suggested by the problem under consideration. Suppose also that it is known *a priori* which constraints will be satisfied as a tight constraint in the dual optimal solution of each firm, and that if a constraint is tight, its dual variable is proportional to the corresponding macro dual variable $\bar{y}_{oi}$ with $1/\lambda_i H_i$ being the factor of proportionality and H_i the number of firms whose ith constraint is tight in the optimal solution. Then the condition (5.2) for exact aggregation of the K firm dual solutions is satisfied. In fact let $\bar{y}=P^+\bar{y}_o=\bar{P}^+\Lambda^{-1}\bar{y}_o$, where $\bar{P}^+$ is the Moore-Penrose generalized inverse of $\bar{P}$. Since $\bar{P}$ is assumed of full rank, its generalized inverse is $\bar{P}^+=\bar{P}(\bar{P}'\bar{P})^{-1}$. Hence multiplying $\bar{y}=\bar{P}^+\Lambda^{-1}\bar{y}_o$ by P' one obtains $P'\bar{y}=P'\bar{P}^+\Lambda^{-1}\bar{y}_o=\Lambda\bar{P}'\bar{P}(\bar{P}'\bar{P})^{-1}\Lambda^{-1}\bar{y}_o=\bar{y}_o$, which is condition (5.2).

Note that the aggregation conditions for the primal and the dual solutions do not have to hold simultaneously (see the numerical example presented in Table 2). It is admissible and possible, therefore, to have exact aggregation in only one of the dual pair of problems. In some empirical studies this may be all that is required. Finally, if $c'G^+=c_o'$ and $b'\Lambda^{-1}\bar{P}^+=b_o'$, the condition for exact aggregation of the objective function (5.3) is satisfied.

An exemplifying illustration of *Case 3* is presented in Table 2. Three firms with technical matrices of different dimensions, as well as nonproportional vectors of resources and net revenues, have primal solution vectors which satisfy the perfect aggregation requirements. The dual solution vectors, however, do not satisfy the corresponding requirements. Note that in this example $c'\bar{x}=c_o'\bar{x}_o$.

Conclusions

The discussion presented above has demonstrated that it is possible, without great difficulty, to formulate sufficient conditions for exact aggregation more general and less binding than those proposed by Day. As to their application in empirical research, one must be fully aware of the role of sufficient conditions. Typically, when dealing with the problem of aggregation in an empirical context, the researcher *does not* possess information about the elements of both the firms' and the aggregate problem. Usually, the only type of information available to him is the aggregate information, i.e., A_o, b_o, c_o. He must decide then to which group of firms in the region, or in the sector this aggregate information corresponds. His common way out is to *assume* that (utilizing Day's conditions, for example) the firms of the region under study exhibit matrices A_k and vectors b_k, c_k, $k=1, \cdots, K$ proportional to the corresponding matrix A_o and vectors b_o, c_o of the aggregate problem. No empirical evaluation of such conditions is usually performed. The literature abounds with works by authors who are apparently satisfied with this approach.

It seems obvious, therefore, that if the aggregation problem is to be dealt with *through an assumption* about sufficient conditions, the less restrictive such conditions are, the higher the chance that there will exist firms which either fit those conditions or will not deviate too much from them. Day's conditions exclude *a priori* the existence of such firms.

If the researcher is not satisfied about meeting the aggregation problem with an assumption on sufficient conditions (and if he has both time and money to spend), he has the following alternative. Considering the conditions of *Case 1*, for example, he may use response surface

Table 2

	A_1					A_2					A_3				
	4	2	3	1	0	13/3	3	9/4	1	0	4	1	3/4	1	—
	1	3	3/2	0	0	17/24	2	45/32	0	0	3/2	3	3/4	0	--
	1	0	0	0	0	1	0	0	0	0	—	--	--	--	--
	0	1	0	0	0	--	--	—	—	--	0	1	0	0	0
	0	0	1	0	1	0	0	1	0	1	—	—	—	--	--
	b vectors					c vectors					$\bar{x}$ vectors				
Firm 1	10	4	3/2	1/2	5/3	3	2	1/2	0	0	3/2	1/2	2/3	1	1
Firm 2	9	2	3/2	--	5/3	13/6	4/5	1	0	0	3/2	—	2/3	1	1
Firm 3	1	2	—	1/2	—	1/2	25/6	2/3	0	0	0	1/2	2/3	0	—
Aggregate	20	8	3	1	10/3	7/3	69/18	13/18	0	0	3	1	2	2	2
	A_o					G					G^+				
	25/6	3/2	2	1	0	1	0	0	0	0	1/2	0	0	0	0
	41/48	3	39/32	0	0	0	1	0	0	0	0	1/2	0	0	0
	1	0	0	0	0	0	0	1	0	0	0	0	1/3	0	0
	0	1	0	0	0	0	0	0	1	0	0	0	0	1/2	0
	0	0	2/3	0	1	0	0	0	0	1	0	0	0	0	1/2
	$\bar{y}$ vectors					1	0	0	0	0	1/2	0	0	0	0
						0	0	0	0	0	0	0	0	0	0
Firm 1	0	1/3	8/3	1	0	0	0	1	0	0	0	0	1/3	0	0
Firm 2	0	32/45	449/270	—	0	0	0	0	1	0	0	0	0	1/2	0
Firm 3	0	8/9	—	3/2	—	0	0	0	0	1	0	0	0	0	1/2
Aggregate	0	16/27	148/81	37/18	0	0	0	0	0	0	0	0	0	0	0
						0	1	0	0	0	0	1/2	0	0	0
						0	0	0	0	0	0	0	0	0	0
						0	0	1	0	0	0	0	1/3	0	0
						0	0	0	0	0	0	0	0	0	0

methods to generate the disaggregated information about the micro elements A_k, b_k, c_k, $k=1, \cdots, K$. This is easily done by specifying different matrices S and R and combining them with the aggregate information about A_o, b_o, c_o. For every specification of the matrices S and R, he obtains a different distribution of firms which he can analyze to determine whether it might either correspond to or approximate the distribution of the firms in the region. Obviously, this approach is meaningless under Day's conditions.

If, on the other hand, the researcher possesses information about the elements of both the micro and macro problems, A_k, b_k, c_k, $k=1, \cdots, K$ and A_o, b_o, c_o, it is a simple matter to verify if it satisfies the sufficient conditions, whether Day's or the more general ones presented in this paper. It is conjectured that the aggregation bias will be smaller under the less binding conditions.

It is the authors' hope that the reflections and results offered above direct attention to the necessity, and at the same time, to the feasibility of a more satisfactory analysis of the aggregation problem in linear programming. They seem to support the idea that the chance of finding a satisfactory and efficient computational procedure rests upon a formulation of the problem which exhibits greater generality.

References

[1] CIGNO, A., "Production and Investment Response to Changing Market Conditions, Technical Know-How and Government Policies," *Rev. Econ. Stud.* 38:63–94, 1971.

[2] DAY, RICHARD H., "On Aggregating Linear Programming Models of Production," *J. Farm Econ.* 45:797–813, Nov. 1963.

[3] ———, "More on the Aggregation Problem: Some Suggestions," *Am. J. Agr. Econ.* 51:673–675, Aug. 1969.

[4] ———, "Exact Aggregation With Linear Programming Models—A Note on the Sufficient Conditions Proposed by R. H. Day—Reply," *Am. J. Agr. Econ.* 51:686–688, Aug. 1969.

[5] FISHER, W. D., *Clustering and Aggregation in Economics*, Baltimore, The Johns Hopkins Press, 1969.

[6] GOLLADAY, F. L., AND A. D. SANDOVAL, "Optimal Development Policy in An Open Regional Economy: A Programming Analysis," paper presented at the Winter Meeting of the Econometric Society, Detroit, Michigan, December 28–30, 1970.

[7] GOREUX, L. H., AND A. S. MANNE, eds., *Multi-Level Planning—Case Studies in Mexico*, Amsterdam, North-Holland Publishing Company, 1973.

[8] HEADY, E. O., AND ALVIN C. EGBERT, "Regional Programming of Efficient Agricultural Production Patterns," *Econometrica* 32:374–386, July 1964.

[9] HEADY, E. O., N. S. RANDHAWA, AND M. D. SKOLD, "Programming Models for the Planning of the Agricultural Sector," in *The Theory and Design of Economic Development*, eds. Irma Adelman and Erik Thorbecke, The Johns Hopkins Press, 1966, pp. 375–380.

[10] KUZNETS, G., "More on Conditions for Exact Aggregation in Linear Programming," unpublished manuscript, University of California, Berkeley, 1971.

[11] LEE, JOHN E., "Exact Aggregation—A Discussion of Miller's Theorem," *Agr. Econ. Res.* 18:58–61, April 1966.

[12] MARENCO, G., "Exact Aggregation With Linear Programming Models—A Note on the Sufficient Conditions Proposed by R. H. Day," *Am. J. Agr. Econ.* 51:684–686, Aug. 1969.

[13] MILLER, THOMAS A., "Sufficient Conditions for Exact Aggregation in Linear Programming Models," *Agr. Econ. Res.* 18:52–57, April 1966.

[14] PARIS, Q., AND G. C. RAUSSER, "Aggregation in Linear Programming," unpublished manuscript, University of California, Davis, 1972.

[15] SENGUPTA, J. K., AND K. A. FOX, *Optimization Techniques in Quantitative Economic Models*, Amsterdam, The North-Holland Publishing Company, 1969.

Communications

HAS SOCIAL SCIENCE RESEARCH AT THE EXPERIMENT STATIONS INCREASED IN LINE WITH SOCIETY'S NEEDS AND CONGRESSIONAL INTENT?*

Changes in the national situation, especially during the past 30 or 40 years, suggest that research emphases should also have changed substantially during that period. It would appear the emphases should have shifted toward more economic evaluation and appraisal of the results of technology research, determination of plausible alternatives, consequences of action taken, and investigations concerned with basic economic problems, marketing, natural resources uses, and rural development, for example. This paper is addressed to the following question: "Did the State Agricultural Experiment Stations shift their emphases toward relatively more social science research during 1940/41–1970/71?" A careful study of the trend in personnel devoted to such research should yield information useful in shaping future strategy to meet more nearly the needs of rural and urban people.

Agricultural and Rural Communities Face Increased Stresses

Unprecedented changes have occurred in American agriculture during the past 40 years. The farm population decreased from 32,393,000 in 1933 to 9,425,000 in 1971, and farm employment fell from 12,739,000 to 4,445,000 [4, pp. 521, 523]. The index of farm production (1967=100) increased from 60 in 1940 to 111 in 1971, and output per manhour rose from 21 to 125 during the period [4, pp. 537, 540]. Increased production per person and size of farm resulted in an exodus of rural farm and rural nonfarm people. Many migrated to cities, ill-prepared for available jobs. They often found themselves residing in slum areas and on relief. Many rural communities which have remained primarily dependent on agriculture are in a state of decline and suffer from inadequate economic opportunities, community services, and other requisites for viability.

The economic problems of farmers were severe in this period. Supply increased faster than demand, creating surpluses and price problems. Many markets for farm products were lost by varying degrees to synthetics, substitutes, and foreign competitors; marketing costs mounted rapidly. New agricultural technology required increasing amounts of capital, and its differential impact on areas brought about many production adjustment problems.

Congress Recognizes the Need for a Shift in Research Emphasis

The Purnell Act of 1925 specifically listed economic and sociological research as areas of needed emphasis. The Bankhead-Jones Act of 1935 provided for expanding research in areas authorized in the previous Acts. The Research and Marketing Act of 1946 and subsequent annual appropriations require that at least 20 percent be expended for marketing research. This Act and the hearings held before its passage clearly emphasized the need for greater input into the economics of marketing research [1, pp. 222–232]. Proposals in subsequent years to eliminate or reduce the expenditure requirements for marketing research have been discouraged by the Congress.

In 1955, the Congress consolidated the Hatch Act and Laws supplementing it into one appropriation using the name of the original Act. The Hatch Act as amended retains the features of the previous acts, including the 20 percent marketing requirement [1, pp. 232–235].

Appropriations for fiscal year 1970–71 and subsequent years have provided for allocating $3 million of Hatch funds to rural development research to be carried out at the state stations. The Rural Development Act of 1972 authorizes additional money beginning in fiscal year 1974.

Research in Agricultural Economics Failed to Keep Pace With Need[1]

Although the amount of research funds expended or allocated to the various departments is not available, useful measures of size of research effort can be made. A careful count of employees receiving station funds for research on a part-time or full-time basis by department was made for 10 year intervals from fiscal years 1930–31 through 1970–71.[2] The analysis covered the 51 state stations, including Puerto Rico, Hawaii, and Alaska.[3] In states such as California and Georgia, which have more than one station and two or more similar departments, personnel were aggregated into one departmental total.

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* Views expressed are those of the author and do not necessarily represent those of the Cooperative State Research Service of the U. S. Department of Agriculture.

[1] For those interested in details relative to data presented, reference is made to the paper presented by the author at the 1972 Gainesville AAEA meeting [3]. A few copies are available in the Cooperative State Research Service, USDA, Washington, D. C.

Despite the passage of the Purnell Act of 1925, in 1930–31 six of the 51 states including Puerto Rico had no agricultural economics research departments, and three were without such departments as late as fiscal year 1940–41. Of the states with agricultural economics departments in 1930–31, five had two departments, one of these generally being restricted to farm records. Ten years later, four states had second departments. In subsequent years, these were consolidated into one department in each state.

In 1940–41, 396 employees received station funds to carry out agricultural economics research. At the same time, 3,609 employees were engaged in biological and physical sciences research; work in the latter areas was thus well established by that time. A look at 1970–71 showed 1,076 station employees doing agricultural economics research compared with 10,002 in the biological and physical sciences. During the 30 year period 1940–41 to 1970–71, the number employed in agricultural economics thus increased 171 percent, and the number in biological and physical sciences research increased 177 percent. Agricultural economics, although in its embryonic stage in 1940–41, actually did not quite keep pace with or gain on the more established lines of research over the past 30 years.

Agricultural economics has not proliferated into separate departments as has been true in the biological and physical sciences. In 1970–71 only four stations had more than one department receiving station funds for economics research.[4] The number of departments in the biological and physical sciences, despite many consolidations in recent years, showed a net increase from 510 in 1940–41 to 637 in 1970–71, a gain of 127, or 2.5 additional departments per station. Furthermore, when the established departments were consolidated, they generally operated as divisions or groups under a leader with no reduction in personnel. Another item that should be of interest to the agricultural economist and administrators is the relative size of the agricultural economics departments measured in terms of numbers of staff receiving station funds. The agricultural economics departments have more often ranked seventh or lower than first or second in numbers of staff receiving station funds. In 1970–71, 41.2 percent ranked fifth in size or lower compared with 21.6 percent ranked first and second.[5]

Reference should also be made to the sociological research at the state stations. There were seven rural sociology or sociology departments with 19 staff members receiving station support in 1930–31, and 19 departments with staffs totaling 115 in 1970–71. In terms of percentage, this is a significant increase. However, it must be noted that in 1970–71, 32 state stations had no such departments. Of course, a few rural sociologists are frequently found in combination departments, usually designated as agricultural economics and rural sociology. Except for Pennsylvania and Iowa (before its department of Rural Sociology was created), the number of staff per station in this discipline has seldom exceeded two or three. No attempt was made here to identify such personnel separately, and they are counted among those receiving station funds in the agricultural economics departments. If persons engaged in sociological research had been deleted from the count of agricultural economists, the lag in relative growth in agricultural economics would have stood out more.

Despite the additional funds and the wording of the acts under which they were appropriated, between fiscal years 1940–41 and 1970–71, the number of staff members receiving station funds in the agricultural economics departments, plus the economists in other departments, showed no relative increase. That is, the number of agricultural economists was only 11.0 percent as large as the number in biological and physical sciences in 1940–41 and 10.8 in 1970–71. The question arises as to whether marketing funds were used, at least in part, in lieu of Purnell and other funds. The latter were apparently diverted to production departments. Funds for research in agricultural economics, other than marketing, actually declined 20 percent from 1940–41 to 1948–49, a substantial reduction when inflation that occurred during the period is considered.[6]

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[2] The counts were made from handbooks [5]. Employee numbers were aggregated by departments when a state had two or more stations. The percentage of time devoted to research has probably not changed significantly by disciplines. If anything, the increased student enrollment in agricultural economics in recent years may have reduced the percentage of time economists devoted to research. Home economics departments were not included because the research programs often include social science, biological science, and physical science research. Departments such as information, publications, and statistics with the responsibility of servicing all departments were also not included.

[3] Puerto Rico, Hawaii, and Alaska are included because they received Federal grant funds throughout 1930–31 to 1970–71.

[4] The second departments in 1930–31 and 1940–41 were consolidated in later years. These four departments were new ones, generally with objectives different from those of the departments that were consolidated.

[5] Calculations were made from tables referred to in [3, 5].

[6] Although expenditure data by department and by funds are no longer available, for many years such data were summarized by OES (now called CSRS) for limited use. The author received complaints from some department heads that they were losing about as much Purnell and other funds as they were receiving in the form of new Re-

In 1970–71, of the 20 percent required to be expended for marketing, only 43 percent of these expenditures were being used for research concerned with the economics of marketing. The remainder, or 57 percent, was utilized for technological research, usually in food science classified as marketing [2].

Greater Effort Needed To Expand Agricultural Economics Research

All technological developments require adjustments on the part of people. Therefore, it also behooves state stations to do research that is concerned with enabling the people affected to make the best adjustments possible. It is difficult, of course, for research administrators to shift research emphasis, especially at the discipline level, when there is no growth in funds, but funds received grew substantially from 1940–41 to 1970–71. Therefore, one is prompted to ask why and how is it that research effort in agricultural economics did not keep pace with other research. The new funds did not entail the reallocation of money from current lines of research. They permitted more staff across the board. These aspects have been recognized by the department heads and administrators at stations where a broad and comprehensive program in agricultural economics has been developed.

The fact that some stations have developed a broad and comprehensive research program in agricultural economics indicates that with a strong leadership in the department and a favorable environment, relative growth can be achieved. Switching staff from one area to another, giving up nearly as much old funding as new monies, is not a viable way to develop a strong, well-balanced research program. Successful departments have expanded the dimensions of their research programs requiring the addition of well-trained researchers.

If most agricultural economics departments had been willing and able to expand greatly their research in marketing and at the same time continue to increase research in other areas, such as resource economics, farm management, finance, and rural development, many goals would have been realized and the subject of this paper would have been quite different. Obviously, a department head and staff cannot drift but must exercise much initiative.

Some argue that all departments need not be strong in all areas. This point is not debated here. Such a policy would be just as applicable to the biological and physical sciences. Certainly, specialization would not change the ratio of needs for staff in the various disciplines to the disadvantage of the social sciences.

The station director generally has many proposals for consideration and approval. It is well to keep this in mind because usually the departments which have clearly stated proposals to offer, convincing arguments as to their importance, and promising candidates for employment are the ones most likely to receive increased shares of available research funds.

Agricultural economics could be proliferated into a number of departments, as has been done in other broad areas. Most economists object to such an approach. The alternative, if both greater depth and breadth are to be achieved, is to have agricultural economics departments which are large compared with those in other disciplines. Growth, however, requires a continuing effort, and as a department becomes larger, administration becomes more and more of a full-time responsibility. Those department heads not willing to assume such responsibilities should make way for others who are prepared to do what needs to be done. It will be interesting to see what happens in the departments of agricultural economics and rural sociology with new funds allocated for rural development research. Will researchers simply be shifted from ongoing research to new work, or will the dimensions of departmental research be expanded by the addition of new personnel?

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search and Marketing money. He made summaries by funds and fortunately had these data in his files when he began to prepare this paper.

References

[1] KNOBLAUCH, H. C., E. M. LAW, AND W. P. MEYER, *State Agricultural Experiment Stations,* USDA Cooperative State Experiment Station Service Miscellaneous Pub. 904, Washington, D. C., 1962.

[2] METZGER, H. B., *Marketing Research of State Agriculture Experiment Stations, Past, Present, Future,* USDA Cooperative State Research Service, March 1972.

[3] SMITH, GLENN R., "Has Social Science Research Increased in Line with Society's Needs and Congressional Intent?" paper presented at the meeting of the American Agricultural Economics Association in Gainesville, Florida, Aug. 1972.

[4] U. S. Department of Agriculture, *Agricultural Statistics, 1972,* Washington, D. C., 1973.

[5] ———, *Professional Workers in State Agricultural Experiment Stations and Other Cooperating State Institutions,* Washington, D. C., Fiscal Years 1930–31, 1940–41, 1950–51, 1960–61, and 1970–71.

R^2 IN TSLS AND GLS ESTIMATION

Authors in this journal, as well as in others, often report R^2 coefficients for two-stage least squares (TSLS) equations and sometimes for other (non-least squares) estimators. This perhaps is not a serious problem, but questions of interpretation arise. It seems inappropriate to perpetuate a concept that, at best, is confusing.

For TSLS, several potential problems of interpretation occur. Using conventional matrix notation, one structural equation in a simultaneous model may be written

$$y_1 = Y_1\alpha_1 + X_1\beta_1 + e_1. \tag{1}$$

If computations actually follow two steps, residuals could be computed as

$$\hat{u}_1 = y_1 - \hat{Y}_1\hat{\alpha}_1 - X_1\hat{\beta}_1, \tag{2}$$

where $\hat{Y}_1$ is the computed Y_1 from the first step reduced forms. However, the residuals are usually (and correctly) defined as

$$u_1 = y_1 - Y_1\hat{\alpha}_1 - X_1\hat{\beta}_1, \tag{3}$$

i.e., using the observed Y_1.

First, the reader may have some doubt as to whether R^2 was computed from the residuals in (2) or in (3). Second, if (2) is used, R^2 will be in the range (0, 1), but the result is misleading in the sense that the coefficient is not based on the observed variables in the equation. Third, if (3) is used, R^2 has the range $(-\infty, 1)$, as Basmann pointed out in 1962 [1]. Moreover, Basmann argued that plausible models could have small (near zero or negative) R^2's. In my limited experience, logical models seem to have R^2's near one, but perhaps correct results have been discarded because of small R^2 coefficients. In any case, a coefficient computed from the residuals in (3) cannot be interpreted in the usual way; its range is *not* zero to one.

A similar argument holds for generalized least squares (GLS) estimation, which is becoming more frequent. For instance, a generalized difference transformation, a special case of GLS, is sometimes used to take account of first-order autocorrelation. Again, if the transformed observations are used, R^2 has the range (0, 1), but if the residuals are computed from the original data, then R^2 has the range $(-\infty, 1)$.

$$\text{For } y = X\beta + e, \tag{4}$$

the residual sum of squares is

$$v'v = (y - Xb)'(y - Xb). \tag{5}$$

If b is the conventional OLS estimator, then

$$v'v = y'y - \hat{y}'\hat{y}, \tag{6}$$

where

$$\hat{y} = Xb.$$

Equation (6) follows from the fact that

$$b'X'Xb = b'X'X(X'X)^{-1}X'y = b'X'y. \tag{7}$$

However, assume $E(ee') = \sigma^2\Omega$, and define b as the GLS estimator.

$$b = (X'\Omega^{-1}X)^{-1}X'\Omega^{-1}y. \tag{8}$$

The residual sum of squares may be written

$$v'v = y'y - 2b'X'y + b'X'Xb, \tag{9}$$

but the simplification from (7) is not available. Therefore, since

$$R^2 = 1 - \frac{v'v}{y'y}, \tag{10}$$

the usual interpretation applies for the OLS residuals defined by (6) but not for the GLS residuals defined by (9).

In conclusion, when ambiguity is possible, authors should at least tell the reader how R^2 was computed, but the preferable approach would be to use other statistics to appraise results.

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Reference

[1] BASMANN, R. L., "Letter to the Editor," *Econometrica* 30:824–826, Oct. 1962.

LONG-RUN IMPLICATIONS OF A TAX IN KIND TO REDUCE SUPPLY AND INCREASE INCOME: COMMENT

Professor Heady [3] shows in the short run that taxing a percent of the physical production away from farmers will result in increased profits whether the government withholds or sells its share on the domestic market. For his short-run analysis Professor Heady made the following assumptions: (1) a price elasticity of demand for agriculture of less than unity, (2) perfect competition, (3) perfect knowledge, and (4) *n* firms in the industry with identical production functions. The beginning position of Professor Heady's analysis starts with "the absence of any policy to modify supply," and equilibrium starts where profits are greater than zero ($\pi > 0$).

The results of Professor Heady's short run analysis do not necessarily carry over to the long run. For example, profit in agriculture must necessarily be greater than zero because of the type of algebraic production function that Professor Heady used in the analysis and because profit includes fixed costs. For any output greater than zero, marginal costs must be above average variable costs with Professor Heady's function. Therefore, average variable costs will be less than the price of the product where demand is equated with supply. This suggests that the algebraic function Professor Heady used is inappropriate for long run analysis and that he did not intend it for this purpose. We would argue that a policy mechanism is of very limited value if it is good for only a short run situation. Our comments will consider a long run extension of the case where the government withholds its share from the market.

Short run versus long run implications are illustrated in Figure 1. Using Professor Heady's algebraic function, the industry average variable cost curve would be AC and the marginal cost curve or supply curve would be S_0. Therefore supply is equal to demand at point e, price of the product is $0k$, average cost to produce the product is $0m$, and profit is $mkef$. In this example, $0m$ is $\frac{1}{2}0k$ and profit is $\frac{1}{2}0ked$ due to the characteristics of Professor Heady's equation.

Conversely, using S_0 as the long run supply curve and using Professor Heady's basic assumption of perfect competition and perfect knowledge and the additional long run assumption of freedom of entry and exit, the industry's average cost curve would be AC'. Profits are zero and the industry is in long run equilibrium. Taxing part of the farmer's physical output away would cause pure profits in the short run due to the restricted supply just as Professor Heady indicated. However, in the long run, more firms or cropped acres could be expected to enter the industry causing the supply curve to shift to the right (assuming constant factor prices) until profits were again zero.[1] The results of the policy mechanism after long run adjustments, with freedom of entry and exit, would be zero profits and greater total output of agriculture products than before the tax in kind was introduced.[2]

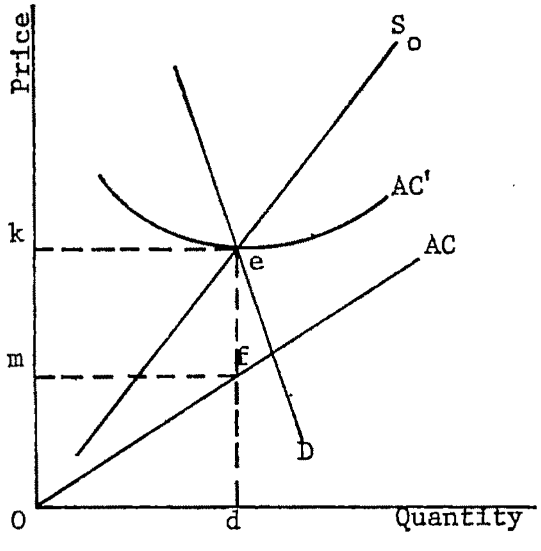

Figure 1. Comparison of short run and long run effect of a tax in kind

Based on perfect competition, if one wants to extend the analysis to the long run and have profits exist, it would be necessary to restrict entry and exit of firms. However, if implicit costs[3] are removed from average costs and some assumptions are made about implicit costs of the farmer and non-farmer, pure profits can exist in the long run. In this case, Professor Heady's algebraic function would be appropriate to use for a long run analysis. Assume that the implicit costs of a farmer (IC_F) plus his pure profit (π/n)[4] is less than or equal to the implicit costs of a non-farmer (IC_N):

$$IC_F + \frac{\pi}{n} \leq IC_N.^5$$

It will be assumed that all non-farm production is engaged in perfect competition and that the pure economic profit is zero. In this case long run equilibrium can exist with pure profits in farming if the value of the next best alternative employment for a farmer (implicit costs which may be considered as wages the farmer pays himself) plus profits from farming are less than the value of the next best alternative employment for the non-farmer. However, if at any time

$$IC_F + \frac{\pi}{n} > IC_N,$$

then some non-farm individual will move into farming until

$$IC_F + \frac{\pi}{n+m} \leq IC_N$$

where m is the number of new farmers.[6]

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[1] Entry can be viewed in several ways. For example, entry can be addition of new farmers or farmers may begin cropping land previously diverted, bring marginal land into production, or intensify production on current acres.

[2] This situation occurs when the government holds its share off the domestic market. This means there is less agricultural product marketed in the U. S. even though total output increases compared to the before program position.

[3] We use Ferguson's definition of implicit cost. "*Definition:* the implicit costs incurred by an entrepreneur in producing a specific commodity consists of the amount he could earn in the best alternative use of his time and money. He earns a pure economic profit from producing X if, and only if, his total receipts exceed the sum of his explicit and implicit costs" [1, p. 165].

[4] Total profit for the industry is π, therefore, individual profit is π/n.

[5] It must be assumed in this analysis that $\pi/n \geq 0$ or farmers would move out of agriculture.

[6] One might raise the point here that if a tax in kind is placed on all agricultural commodities, the entry of new

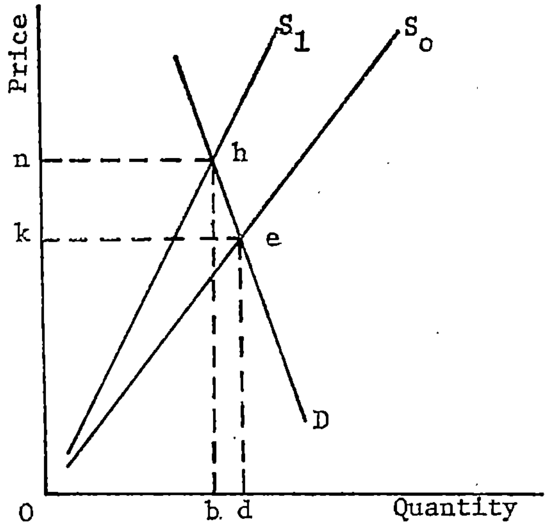

Figure 2. Geometric illustration of effects on price, supply, and market revenue

For the analysis we will examine two different situations. For the first situation, assume that the initial condition is

$$IC_F + \frac{\pi_0}{n} = IC_N.$$

Using Professor Heady's graph (Fig. 2), let S_0 be the market supply curve and D be the market demand curve such that $0d$ quantity is produced. Price is $0k$, market revenue is $0dek$, and industry profit (π_0) is $\frac{1}{2}0dek$ (based on Heady's algebraic equations). An individual's profit is π_0/n.

With some tax on physical production, the market supply curve shifts left to S_1.[7] Now the quantity marketed is $0b$ at price $0n$, and profit (π_1) is $\frac{1}{2}$ $0bhn$. Since $\pi_1 > \pi_0$, there will be the condition

$$IC_F + \frac{\pi_1}{n} > IC_N$$

which implies that non-farmers will move into the industry.[8] The influx of new farmers will cause the supply curve to shift from S_1 toward S_0 until the point is reached where the implicit cost plus profits of the old and new farmers is equal to the implicit cost of the non-farmer.[9] This will be at some point between the S_1 curve and the S_0 curve. Profit per farmer at this point can be expressed as $\pi_2/(n+m)$ where there are n old farmers and m new farmers. The final equilibrium conditions are

$$IC_F + \frac{\pi_2}{n+m} = IC_N \text{ and } \frac{\pi_0}{n} = \frac{\pi_2}{n+m}$$

so that the individual profit is unchanged. This tax in kind has increased cost to consumers, reduced marketed output, and left the farmers in the same individual profit situation as before, only now there are more farmers. Also, the government has the problem of how and what to do with its share.

In the second situation we will assume that the initial condition is

$$IC_F + \frac{\pi_0}{n} < IC_N.$$

With some tax on physical production, the market supply curve shifts left to S_1 (using Fig. 2 again). From this situation, two possible conditions can evolve. In the first condition after the tax, profits are raised sufficiently such that

$$IC_F + \frac{\pi_1}{n} > IC_N.$$

Non-farmers will move into the industry until

$$IC_F + \frac{\pi_2}{n+m} = IC_N,$$

but in this case the final equilibrium will be such that

$$\frac{\pi_2}{n+m} > \frac{\pi_0}{n}.$$

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farmers brings no further land into production. The new farmer merely produces on the land released by current farmers. The "1972 OBERS Report," which is scheduled to be released February 9, 1973 by the Economic Research Service, contains projections of population and economic activity to the year 2020. This report estimates that cropland availability for the production of food and fiber for the U. S. in 1980 will be approximately 457 million acres and, of this, 122 million acres will be idle cropland and/or cropland pasture. These figures were estimated using the existing land base, expected increase in land through development, and expected decrease due to non-agricultural uses. Based on these estimates, there is a considerable amount of land available that is not in production and that current farmers could conceivably release to new farmers. This is assuming, of course, that all land is homogeneous. Theoretically, when profits are made in the short run, because of a tax in kind on all agricultural commodities, a new farmer could enter farming with a firm identical to the current farmer. It must also be remembered that only field crops need large additional amounts of land for increased production, whereas meat, poultry, and dairy products could probably be produced on less land than now used. "Entry" could also take the form of existing farmers bringing more land, labor, or capital into production.

[7] Market supply curve refers to the actual quantity marketed and not the total supply produced.

[8] One may consider non-farmers moving into agriculture as only theoretically possible. However, the 1969 Census of Agriculture reports that for the state of Texas, of the Class 1–5 farms, that the number of farms increased from 96,115 in 1964 to 120,798 in 1969 and that the size of these farms decreased from 1287.2 acres per farm in 1964 to 1078.1 acres per farm in 1969 [5, p. VII]. This movement held for only a few states in 1969, but it is evidenced that new farmers can and do move into agriculture.

[9] This assumes the profit of non-farm producers remains zero. This is a legitimate assumption since total personal income of the farm section was only 2.5 percent of the total personal income of the non-farm sector in 1970 [2, p. 102].

In this situation, the tax in kind has increased farmer profits and has also increased cost to consumers, reduced marketed output, and increased the number of farmers.

In the second condition, after the tax, profits are raised such that

$$IC_F + \frac{\pi_1}{n} \leq IC_N.$$

In this case there would be no incentive for nonfarmers to move into farming. Therefore the tax in kind has increased profits for farmers and has also increased cost to consumers, reduced marketed output, and left the number of farmers unchanged. Only in this last situation does Professor Heady's short run analysis and our long run analysis coincide.

Another important point that should be investigated is the agricultural policy immediately prior to the tax in kind. Professor Heady starts his analysis with "the absence of any policy to modify supply." If a tax in kind policy were to be used, it would probably replace a policy that is now in existence. Suppose this tax in kind is to replace a farm policy on a commodity that uses some type of diverted acres program (in this analysis we will hold the number of firms fixed). The effect of changing from a diverted acre policy to a tax in kind policy on this commodity would be to shift the production function up (since farmers are free to produce any amount they want). That is, an increase in the amount of land would cause an increase in total production for any given amount of variable input. Thus, where Professor Heady shows the effect of the tax by changing the production function from $Q_p = \alpha X^{1/2}$ to $Q_p = .8\alpha X^{1/2}$ (Heady used a tax of .2), we would change the production function from $Q_p = \alpha X^{1/2}$ to $Q_p = .8\delta\alpha X^{1/2}$. The value of δ is one plus the amount by which the production function has shifted up due to converting diverted acres to production.

Following Professor Heady's example, we obtain the following equilibrium values:

$$P_3 = 1.25^{4/3}\delta^{-4/3}P_0$$
$$Q_3 = .8^{2/3}\delta^{2/3}Q_0$$
$$TR_3 = .8^{-2/3}\delta^{-2/3}TR_0$$
$$TC_3 = 1.25^{2/3}\delta^{-2/3}TC_0$$
$$\pi_3 = 1.25^{2/3}\delta^{-2/3}\pi_0$$

where P_0, Q_0, TR_0, TC_0, and π_0 would be the equilibrium values under the diversion program. The profit equation (π_3) indicates: if $\delta < 1.25$, farmers would profit under the tax in kind program; if $\delta = 1.25$, they would have the same profit as before; and if $\delta > 1.25$, farmers would have less profit than before.

In 1971 the major crops under the diversion program were feed grains, wheat, and cotton. Approximately 185 million acres of these crops were planted [4, pp. 3–75], and 38 million acres were diverted [4, p. 637]. To change from diverted acres program to the tax in kind program for these crops could mean an approximate 20 percent increase in the acreage planted of these crops if all farmers use all their diverted acres for these crops. (They could also bring in marginal land not previously used in production.)

Now if $\delta = 1.20$, then

$$1.20^{2/3} < 1.25^{2/3}$$

which implies

$$\pi_3 > \pi_0.$$

However, in 1971 farmers received approximately $2.75 billion in direct payment [4, p. 635] from the government for these crops. So, for farmers to have an increase in profit, the following condition is necessary:

$$\pi_3 > \pi_0 + \text{government payments.}$$

There are other points that need clarification which Professor Heady may not have addressed since he was primarily concerned with the basic implications of a tax in kind. For example, Professor Heady states that "... the program could be applied to a single commodity without close substitutes, to commodity groups that embrace all close substitutes or all commodities of the farm sector." Professor Heady is obviously referring to the marketing of the commodities and may not have adequately considered how the individual farmer will allocate his scarce resources among the commodities he produces. Commodities that are not close substitutes on the marketing side still compete for the same scarce resources on the production side. An example might be a farmer who produces cotton and grain sorghum or a farmer who produces corn and hogs.

Let us assume that a farmer produced commodities Y_1 and Y_2 which are not close substitutes on the marketing side. Assume that X is the only resource used to produce Y_1 and Y_2. The farmer produces amounts of Y_1 and Y_2 such that the marginal value product per dollar of X is equal for Y_1 and Y_2 and both equate to 1 or

$$\frac{MVP_{X(Y_1)}}{P_X} = \frac{MVP_{X(Y_2)}}{P_X} = 1.0$$

where MVP is marginal value product and P_X is price per unit of factor X.

Now assume a tax is placed on Y_1. From the farmer's point of view, the physical productivity of resources will decline, i.e., he receives only a proportion of each unit of product that he produces. Therefore the marginal physical product curve will shift left; however, this is not the important consideration. The shift that occurs in the marginal value product curve is the most important consideration. This shift in the marginal value product curve indicates adjustments in resources between products produced. With an inelastic demand for a commodity, a reduction in supply is associated with a proportionately greater increase in price. If, for the initial taxed position, an increase in the price of Y_1 more than offsets the decline in physical productivity as conceived by the farmer due to a tax in kind, then we could expect a change from the original equilibrium position to

$$\frac{MVP_{X(Y_1)}}{P_X} > \frac{MVP_{X(Y_2)}}{P_X} = 1.$$

This indicates that additional resources will be applied to Y_1 or in the case of limited capital, resources will be shifted from Y_2 and applied to Y_1 ignoring problems of plant fixity. For the first case, more total Y_1 (the taxed commodity) would be produced by farmers (less is marketed given the government does not release its share on the domestic market). The incentives provided attract more resources into agriculture. With limited capital, more Y_1 and less Y_2 would be produced. For this situation, if Y_2 is characterized by inelastic demand, then the tax could very well increase farmer profits from the sale of both Y_1 and Y_2. However, it would be reasonable, with the increased returns per dollar of resources used in both Y_1 and Y_2, to expect these increased returns to attract additional resources into agriculture. Therefore, we would argue in either case, the tax program would attract some additional resources to agriculture due to the prospect of greater profits.

Turning to the other possibility concerning the shift in the marginal value product of Y_1, we have

$$\frac{MVP_{X(Y_1)}}{P_X} < \frac{MVP_{X(Y_2)}}{P_X} = 1.$$

Resources would be withdrawn from Y_1 and Y_1 output reduced, but due to the equilibrium conditions for Y_2, its output could not be affected. However, with limited capital, resources would be shifted from Y_1 to Y_2. If Y_2 were characterized by an inelastic demand, then profit from Y_2 would decline negating somewhat the favorable profit response obtained for Y_1.

To examine the situation for a tax on all commodities and for simplicity, assume that the tax does not change the proportion of the resource X going to each commodity, so all commodities may be referred to as one commodity Y. The initial condition before the tax is

$$MVP_{X(Y)} = P_X.$$

After the tax there are two possible conditions that could exist. First, if after the tax the condition is

$$MVP_{X(Y)} < P_X,$$

then this implies that resources would be shifted out of agriculture. However, the second possible condition immediately following the tax could be

$$MVP_{X(Y)} > P_X.$$

This second situation would be expected if the government did not place its share on the domestic market. With the marginal value product greater than the price of resources, the incentive would be to purchase additional resources in agriculture which would result in an overall increase in total agricultural output and an increase in resources used in agricultural production. It is agreed that with the government holding its share off the domestic market, less would be marketed but nevertheless more total product would be produced. This leaves the government with the task and expense of handling, storing, shipping, and preserving its share. We would wonder if this cost might not approach the present expense of agricultural farm programs. Therefore, we could visualize a situation evolving where government costs are not reduced, consumers' costs for agricultural products are increased, and, yes, in some cases profits to the farmers are increased.

In conclusion, this is not particularly a criticism of Professor Heady's article, but rather an addition to it. We are concerned that there appear to be several cases where a tax in kind would distort resource allocation in agriculture and not increase farmer profits. In going to the long run implications, we have reservations that the tax in kind would, indeed, result in a situation where the farmer could "have his cake and eat it too."

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References

[1] FERGUSON, C. E., *Microeconomic Theory*, Homewood, Illinois, Richard D. Irwin, Inc., 1966.

[2] GRIFFIN, WADE L., *The Relationship Among Income, Labor Productivity, Property Taxes, and Migration, U.S. Agriculture, 1957–1970*, unpublished Ph.D. thesis, Oregon State University, Corvallis, 1972.

[3] HEADY, EARL O., "Tax in Kind to Reduce Supply and Increase Income Without Government Payments and Marketing Quotas," *Am. J. Agr. Econ.* 53:441–447, Aug. 1971.

[4] U. S. Department of Agriculture, *Agricultural Statistics, 1972*, Washington, D. C., 1973.

[5] U. S. Department of Commerce, Bureau of the Census, *1969 Census of Agriculture Volume 1, Area Report, Part 37, Texas, Section 1, Summary Data*, Washington, 1971.

LONG-RUN IMPLICATIONS OF A TAX IN KIND TO REDUCE SUPPLY AND INCREASE INCOME: REPLY

Griffin and Lacewell do not offer a critique of my analysis. As they indicate, it is more an extension of my short-run analysis into a long-run context. The two are not necessarily or not obviously in conflict, and I did not present my analysis as long-run. As they well illustrate, the theory can be extended in many directions. Theirs is one extension. Crown and I offered another extension or modification in a subsequent short-run analysis [1]. Other extensions also are possible, and it is well that we have several for a policy means which already has some indications of acceptance (e.g., commodity check-offs) and perhaps considerable promise.

The major promise of my analysis is as a short-run tool, and I used it in this context because the orientation and intense concern over agricultural policies have always been the short-run. Policies put in practice over the last several decades have never been attempts to bring farm firms or commodity sectors to a long-run equilibrium, but rather attempts to create greater short-run profits (i.e., an increase of revenue over variable costs). Generally, too, the actual short-run policies of recent decades alone have had the effects of increasing the firm's demand for resources (more capital technologies, a larger land area per farm, etc.). Long-run conditions are not unique in this sense. Actual short-run policies sometimes were ineffective because their supply control fixtures were not stringent enough to offset the increased demand for inputs; policies brought inequities to agriculture because some firms greatly increased their demand for resources and absorbed a major proportion of public payments; and/or policies tightened controls to an extent which offset increased input demand at the support level of prices or resource returns sought or attained.

Farm policies in the U. S., especially those of supply control, have never been aimed at long-run equilibria. If firms and the industry were already at long-run equilibrium, not only in terms of first-order and second-order firm conditions but also in terms of returns to resources in agriculture at levels of all other sectors, there would be zero need for any supply control policy—and probably near-zero interest of farmers for such policy. Hence, outside of the economist's academic interest in it, long-run equilibrium criteria for agricultural policy will largely be the concern of an occasional conservative Secretary of Agriculture obsessed with returning agriculture to a free market. This was the reason for my focus on the short-run. However, Griffin and Lacewell have made an important contribution in extending the theory to the long-run and in detailing certain short-run facets obvious in my model but for which I lacked space. This is true and obvious for the case in which the tax is applied to one commodity but not another or where a supply control program already is in effect. We could add other variations to the general theory by turning the tax to selected inputs or the entirety of inputs, by tracing its income and resource demand effects as taxes on selected outputs or inputs impinge differently on various geographic, commodity, or income groups, or by evaluating different rates of taxation for different income strata. The theory is quite general for both short-run and long-run situations, as Griffin and Lacewell have well indicated in their extensions.

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Reference

[1] HEADY, EARL O., AND ROBERT W. CROWN, "Toward an Optimal Policy of Supply Control and Farm Income Improvement," *Canadian J. Agr. Econ.* 20:40–50, Sept. 1972.

RELIABILITY OF USING THE MEAN ABSOLUTE DEVIATION TO DERIVE EFFICIENT *E*, *V* FARM PLANS: COMMENT

In a recent article Thomson and Hazell [3] investigated the relative efficiency of using the mean absolute deviation (*MAD*) to approximate efficient *E*, *V* farm plans. The efficiency criterion was essentially calculated as a function of expected utility loss between two farm plans with similar expected income but different variances. The resultant measure was found to be a function of the variance ratio of the two farm plans. A simulation experiment was conducted for a wide range of variance ratios, correlations, and sample sizes.

The purpose of this note is to prove that the efficiency criterion used by Thomson and Hazell is biased. We shall first illustrate the bias through the graphical representation of the efficient farm plans. A measure of ranking different farm plans is also shown in the analysis that follows. Consider Figure 1 in which the familiar *E*, *V* efficient frontier and the

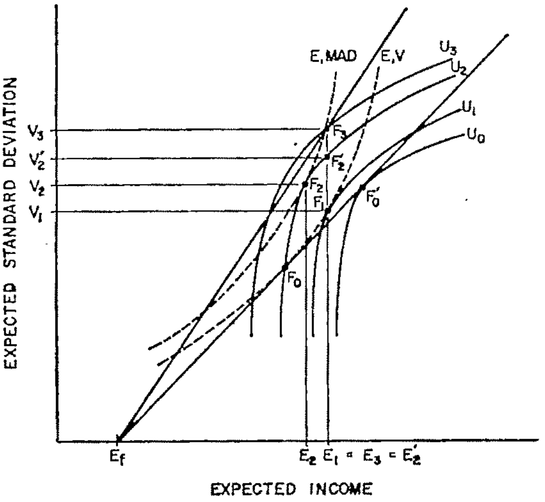

Figure 1. ***E*, *V* vs. *E*, *MAD* efficient farm plans**

indifference curves U_1, U_2, and U_3 of the farmer are shown. The *E*, *MAD* efficient frontier is also plotted but on the left of the *E*, *V* efficient frontier.[1] The optimum farm plan chosen by the farmer is the one at the efficient frontier tangent to the indifference curve with the highest utility. The question of relative efficiency is this: what is the loss in expected utility to the farmer if he had chosen the optimum farm plan (F_2) based on *E*, *MAD* instead of the optimum farm plan (F_1) based on *E*, *V*? Loss in expected utility is simply $EU(F_1)-EU(F_2)$. However, these are not the two farm plans compared by Thomson and Hazell. Instead, they compared farm plan F_1 with another farm plan, F_3. that has the convenient property of having the same expected income as F_1.[2] Since only in rare instances would F_3 equal F_2, F_3 in general is not an optimum farm plan to the farmer, i.e., $EU(F_3)\neq EU(F_2)$, and comparison based on the criteria $EU(F_1)-EU(F_3)$ is biased.

To calculate the expected utilities U_1, U_2, and U_3, assume that the farmer's expected utility could be represented by the quadratic function of the form:[3]

$$EU(E, V) = aE - bE^2 - bV. \tag{1}$$

The difference in expected utility from farm plan F_1 to farm plan F_2 can now be written as

$$\begin{aligned} EU(F_1) - EU(F_2) &= a(E_1 - E_2) - b(E_1^2 - E_2^2) \\ &\quad - b(V_1 - V_2). \end{aligned} \tag{2}$$

Due to lack of knowledge concerning the values of *a* and *b*, the sign and magnitude of (2) may not be unambiguous. Fortunately, there is an alternative method of calculating the loss in expected utility. We note that there is another farm plan, F_2', which lies on the same indifference curve (U_2) as F_2, whose expected return E_2' is equal to those of E_1 and E_3. Thus the expected utility loss calculated between F_1 and F_2, or between F_1 and F_2', is equivalent. Rewriting expression (2) and substituting $E_1=E_2'$, one obtains

$$EU(F_1) - EU(F_2') = -b(V_1 - V_2') = b(V_2' - V_1). \tag{3}$$

Loss in expected utility for the risk averse farmer is positively related to the incremental increase in expected variance due to the less efficient farm plan. It is also negatively related to the farmer's degree of risk aversion, i.e., the more the farmer is averse to risk, the greater is the loss in expected utility from choosing *E*, *MAD vis-à-vis* the *E*, *V* farm plan.

On the other hand, Thomson and Hazell compared farm plans F_1 and F_3. The loss in expected utility in this case is, simply,

$$EU(F_1) - EU(F_3) = -b(V_1 - V_3). \tag{4}$$

The bias introduced by using (4) instead of (2) or (3) could be calculated as

$$EU(F_3) - EU(F_2) = b(V_3 - V_2'). \tag{5}$$

Thus far our discussion is concerned only with expected utility loss to the individual farmer. Unless the utility function of the farmer is explicitly known, the method outlined above may not be feasible. However, if interest is in ranking farm plans, then there are available measures of portfolio efficiency, such as the Sharpe Index [2], that could be adopted for this purpose. If farmers have the choice of either borrowing or lending at the rate of E_f, due to separation theory, the line that emanates from E_f and is tangent to the efficient frontier at, say, F_0 would comprise all the efficient farm plan combinations for all farmers. In other words, risk averse farmers with different utility functions will attain higher levels of utility by choosing a farm plan consisting of F_0 and E_f instead of the one on the efficient frontier which is tangent to their utility curves. Hence, all farm plans chosen by different farmers, e.g., F_0', will lie on the same line E_f, F_0 with the slope

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[1] The curves portray the general case of *E*, *MAD* efficient frontier not to be more efficient than the *E*, *V* efficient frontier. See [1] and [3], especially for large samples. The following analysis is, of course, applicable to the unlikely situations where the positions of the two curves are reversed, e.g., the assumptions of *E*, *V* are violated.

[2] By parametrization of *E* in the mathematical programming solution, the efficient frontier of optimum farm plans is the one with the minimum *V* at each *E*. However, only one of the two farm plans with fixed *E* could be optimal.

[3] See equation (1) in [3]. As is well known, the *E*, *V* formulation is based exclusively on the first two moments of the distribution of returns, and the quadratic utility function is the only function that depends solely on the first two moments of the distribution. Note that the quadratic utility function is $U=aE-bE^2$, and the expected utility is the expression in equation (1). Thus, Thomson and Hazell's equation (1) should be preceded by the expected utility operator, and their equation (2) should be more appropriately expressed as the difference in "expected" utility.

$$(6) \qquad \frac{V_1}{E_1 - E_f}$$

or the inverse

$$(6.1) \qquad S = \frac{E_1 - E_f}{V_1}.$$

It is obvious that the most efficient farm plan should have the highest value of S, and the next most efficient farm plan the second highest value of S, and so on. Then S could be employed as a general index to rank relative efficiency of farm plans with different E, V combinations, i.e., E's need not be kept constant. The method will give the same ranking of farm plans for risk averse farmers with different utility functions.

As a final question, it is not entirely clear whether it is the ratio of the income distributions variance or the ratio of farm plans variances that is fixed in Thomson and Hazell's simulations.[4] According to their equations, it is obvious that it should be the variance ratio of the farm plans that should be fixed, although this would require fixing both the expected incomes and the expected variances (population), and calculating the proportions of the two activities in advance. After this, there is not much room for simulations.

The issues raised here should in no way diminish the attractive computational property of the E, MAD approach. However, due to the fact that MAD tends to give lesser weights to extreme values of the distribution than variance, we feel that this type of study will be more fruitful if it is directed to the question of the relative efficiency of farm plans at the extremes of the efficiency frontier.[5]

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[4] Here we are referring specifically to the first paragraph in [3, p. 504]. "Samples of equal specified size were drawn from two income distributions with equal means of specified correlation, and with variances in a specified ratio . . . ."

[5] Our preliminary results seem to bear out the fact that, although the E, MAD efficient frontier function approximates the E, V efficient frontier extremely well, the fit is not as good for a high risk-high return farm plan.

References

[1] HAZELL, P. B. R., "A Linear Alternative to Quadratic and Semivariance Programming for Farm Planning under Uncertainty," *Am. J. Agr. Econ.* 53:53–62, Feb. 1971.

[2] SHARPE, W. F., "Mutual Fund Performance," *J. Bus.* 36:117–138, Jan. 1965.

[3] THOMSON, K. J., AND P. B. R. HAZELL, "Reliability of Using the Mean Absolute Deviation to Derive Efficient E, V Farm Plans," *Am. J. Agr. Econ.* 54:503–506, Aug. 1972.

RELIABILITY OF USING THE MEAN ABSOLUTE DEVIATION TO DERIVE EFFICIENT E, V FARM PLANS: REPLY

Professor Ang approaches the problem of measuring the efficiency of the E, MAD method of estimating the efficient frontier from a rather different standpoint than ourselves. We proposed that the relative performance characteristic to compare is the probability of correct ranking of farm plans by income variance V for given expected income level E. The motivation for fixing E was not a matter of convenience as Professor Ang suggests, but because when using mathematical programming models to derive efficient, E, V, plans, E is parameterized and the minimum variance farm plan is selected for each critical, or basic, value of E. This approach could permit a completely objective appraisal (devoid of utility concepts) of the relative performances of the sample MAD and variance for given sample size n, correlation between farm plan incomes ρ, income variance ratio V_R, and functional form of the income distributions. However, we modified the analysis to take account of the fact that the importance of correct ranking increases with variance ratio (at least for risk-averse individuals) and noted that if individual expected utility functions are of the form

$$E(U) = g(E) - bV$$

[where, for example, $g(E) = E - bE^2$ in Ang's equation (1)], then, independent of their actual expected utility parameters, the difference in expected utility between any two farm plans of equal E is proportional to the difference in their variances for all individual farmers. Our modification is therefore achieved with very little loss in the generality of the results.

Professor Ang wants to measure the relative performance of the sample MAD in terms of loss in expected utility for an individual given that he chooses from the efficient frontiers estimated with the sample MAD and variance. This analysis focuses sharply on the optimal point and is specific to the individual's utility function (in that the parameters must be known) and of course to the feasibility constraints defining the frontier. Thus his approach not only sacrifices generality but would not provide information on the relative performance of the sample *MAD* for suboptimal decisions, a matter of some importance in a world where individual utility functions are but vaguely located. Consequently, while sympathetic to Ang's desire to extend the analysis in this way, we consider his suggestion both impractical and too narrowly conceived, although we are grateful for his comment that between the (estimated) optimal points, the expected utility loss may be less than the loss estimated by us.

On a more specific level, we wish to disagree with Ang on two counts. First, the set of efficient, E, V plans selected with the sample *MAD* need not always be less efficient than the set selected with the sample variance. It is quite possible for the two estimated frontiers to intersect, sometimes repeatedly, and our simulation results also show that the sample *MAD* sometimes performs consistently better than the sample variance when income distributions are asymmetric. However, we would like to point out that the efficiencies dealt with in our paper concern the determination of the plans underlying these frontiers by comparison, through rival techniques, of two random variables, one distributed according to the plan on the frontier, the other distributed according to a plan above the frontier. We were not concerned with the positions of the frontiers *per se*, for as pointed out in our note [1], the estimation involved here "may make use of any estimation procedure considered desirable" once the "best" plan (in terms of activity levels) has been settled on.

Secondly, we consider that our results are applicable for all feasible values of E, including extreme values on the efficiency frontier. This is precisely why we chose to undertake a general analysis and why we object to Ang's concentration on the expected utility loss between optimal farm plans. Furthermore, the fact that the *MAD* gives less weight than the variance to extreme values of a distribution will affect the ranking of any two farm plans of unequal variance, regardless of the magnitude of their individual variances. It is the variance ratio that counts, and this is not specific to any location on the efficient frontier.

Finally, we wish to clarify the nature of the variance ratios used in the simulation study. We did not construct specific farm plans or specify any farm activities. We merely postulated that the income associated with any farm plan is a random variable, being drawn from an income distribution with mean E and variance V. Specifying population values for these parameters therefore sufficed to characterize farm plans, and the variance ratios used were the ratios of the V values chosen. This reduces the problem to ranking income distributions, and the fact there is a correspondence between each pair of E, V parameters and a set of activity levels is quite immaterial to the problem.

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Reference

[1] THOMSON, K. J., AND P. B. R. HAZELL, "Reliability of Using the Mean Absolute Deviation to Derive Efficient E, V Farm Plans," *Am. J. Agr. Econ.* 54:503–506, Aug. 1972.

PRICE AND INCOME FLEXIBILITIES AND THE DOUBLE LOGARITHMIC DEMAND SYSTEM: COMMENT

Systems of double logarithmic demand functions[1] are often used to estimate price and income elasticities (or flexibilities) of demand for agricultural commodities. Policy makers utilize these demand parameters for the rational formulation of farm policies and programs. Hence, it is important to obtain concise and accurate estimates of these parameters as well as a clear understanding of their appropriate interpretation. This paper considers the theoretical properties of parameters obtained from such demand models. In particular, we wish to call attention to a theoretical weakness in the works of Houck [3] and Waugh [6, pp. 80–84] who have shown that constraints[2] which are imposed on price and income elasticities, by theory, imply a set of corresponding restrictions on price and income flexibilities. Our remarks are directed towards the assumed double-log form for the system of demand functions employed in the two works. That is, the system of demand functions used for reference is

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[1] The advantages and limitations of these functions have been discussed by Houthakker [4] and Goldberger [2].

[2] The constraints are: Engel aggregation, Cournot aggregation, homogeneity condition, and symmetry relation.

$$q_i = A_i Y^{a_i} \prod_j P_j^{e_{ij}} \qquad i = 1, \cdots, n \tag{1}$$

where q_i is the quantity demanded of the (ith) commodity, Y denotes money income, P_j is the price of the (jth) commodity, a_i is the income elasticity of the (ith) commodity, e_{ij} is the cross price elasticity of the (ith) commodity with respect to the (jth) price, and A_i is a constant term.

On taking logarithms and specifying the system in terms of Houck's notation, (1) becomes

$$q' = EP' + a'Y^* \tag{1.1}$$

where the usual definitions apply to the variables. It is well known that the demand functions (1) are inconsistent with utility theory. Except in very special cases,[3] the system of double logarithmic functions does not satisfy the integrability condition and thus cannot be deduced from maximization of a classical utility function [7, pp. 105–107]. The integrability problem, although rather technical, is quite important from an empirical point of view. Although we do not in practice derive such demand functions from utility maximization, it is desirable to know that such functions are specified, interpreted, and restricted in the light of consumer demand theory.[4]

A related and perhaps more serious problem in applied work, assuming the demand functions used above, is that the adding-up-criterion (Engel aggregation) is violated. This criterion may be of little consequence in situations in which only one equation is being estimated. However, in a complete system, which is the frame of reference within which Houck's and Waugh's results fall, violation of the adding-up-criterion destroys the consistency of the results. Another manifestation of the Engel aggregation is concerned with the income elasticities. If we impose the Engel aggregation condition, the income elasticities (or as Houck indicated, price flexibilities with respect to income) must be all equal to one [8, pp. 261–262]. The result that all income elasticities are equal to one follows from the structure of the model and therefore has no practical merit.

Where does this leave us with respect to the results obtained by Houck and Waugh? We note that what they attempted to show is that the flexibilities satisfy conditions which the elasticities themselves cannot satisfy due to the functional form of the demand equations. Hence, although the algebra is correct, the results in the sense that they depend upon the properties of the double-log system of demand functions are of limited interest. The relationships may be of consequence when demand parameters are estimated on market data since it may in some sense be argued that the equations approximate aggregate individual behavior. However, to be of use in more than an *ad hoc* context, the results must be correct for demand functions which exhibit plausible theoretical properties. Examples of the latter functions are found in the Rotterdam demand model [1] and the linear expenditure system of Stone [5].

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[3] In these cases the indifference curves are of an implausible form [7, pp. 105–107].

[4] As we usually use aggregated data for estimating demand parameters, this correspondence holds for properly specified systems of market demand functions only under special circumstances.

References

[1] BARTEN, A. P., "Estimating Demand Equations," *Econometrica* 36:213–251, April 1968.

[2] GOLDBERGER, A., "Functional Form and Utility: A Review of Consumer Demand Theory," Social Systems Research Institute, University of Wisconsin, Systems Formulation, Methodology and Policy Workshop Paper 6703, Oct. 1967.

[3] HOUCK, J. R., "A Look at Flexibilities and Elasticities," *J. Farm Econ.* 48:225–232, May 1966.

[4] HOUTHAKKER, H. S., "New Evidence on Demand Elasticities," *Econometrica* 33:277–288, April 1965.

[5] STONE, R., J. A. C. BROWN, AND D. A. ROWE, "Demand Analysis and Projections for Britain: 1900–1970: A Method," in *Europe's Future Consumption*, ed. J. Sandee, Amsterdam, North Holland Publishing Co., 1964, pp. 200–225.

[6] WAUGH, F. V., *Demand and Price Analysis*, USDA Tech. Bull. 1316, 1964.

[7] WOLD, H., AND L. JUREEN, *Demand Analysis: A Study in Econometrics*, New York, John Wiley and Sons, Inc., 1953.

[8] YOSHIHARA, K., "Demand Functions: An Application to the Japanese Expenditure Pattern," *Econometrica* 37:257–274, April 1969.

PRICE AND INCOME FLEXIBILITIES AND THE DOUBLE LOGARITHMIC DEMAND SYSTEM: REPLY

I have a feeling that Messrs. Green, Hassan, and Johnson (henceforth GHJ) have not read the Comment and Reply [1, 4] published in this *Journal* six months after the appearance of my original article. This omission is forgivable since that exchange probably is not really a classic. However, it does touch on some, but not all, of the issues raised here by GHJ. In particular, I tried to clarify my view of the connection between the theoretical elasticity constraints and double-log estimating equations. But since the question comes up again in a somewhat different vein, "here is another bead on the string of confusions" [5, p. 416].

Theoretical constraints on demand elasticities such as the Engel aggregation condition, the Cournot aggregation condition, the homogeneity condition, and the Slutsky symmetry relation were devised by the pioneering heavyweights in demand theory without much regard to the specific mathematical form of utility or demand functions. (Incidentally, a very good recent summary of all this is to be found in [2].) These constraints refer to small (maybe infinitesimal) changes around any given point on a multi-dimensional demand surface of a fairly general character.

Now look at GHJ's equation (1.1). If q', P', and Y^* are viewed as small *proportional* changes (e.g., dq'/q') in quantities, prices, and incomes respectively, then things begin to clear up [4]. The traditional theoretical constraints apply to the elements in E and a' and are expressed in the matrix notation of my original article.

I then arrived at a similar, but not quite identical, set of constraints on the flexibilities ($F=E^{-1}$) when prices (P') are moved to the left-hand side of the equality. Fortunately, GHJ confirm the accuracy of my algebra. In this context, the double-log equation problem shreds away.

To contradict GHJ flatly, I argue that the results I achieved for flexibilities do not depend in any way on the double-log system of demand functions. If the traditional elasticity constraints hold, then the flexibility constraints also hold. It is a separate problem to select the most useful estimating equation form for the research at hand. However, it is surely true that my original paper did not stress this distinction properly.

I have often observed that double-log functions are convenient in some empirical studies, but I surely do not wish to be billed as the lawyer for these equations. They have strengths and weaknesses, some of the latter pointed out by GHJ. In particular, they cite Yoshihara's [6, p. 261] demonstration that an exhaustive set of double-log demand functions (with q' on the left) must display unitary income elasticities for each and every good if the budget constraint is to hold. Although true enough, this is a mathematical question, not an economic one. It is a limitation of the double-log form used *en masse* but not a weakness in the theoretical apparatus. Nobody, certainly not I, really knows what shape demand curves actually have if, indeed, they have any shape. The angels have not vouchsafed us this information, and I, for one, would be most astonished to learn that they had any simple mathematical form, even in The Netherlands. But to do any empirical work, we must make a selection. So the studies of Barten, Stone, Yoshihara, and others are most helpful, as GHJ observe.

Now I want to comment briefly on one other specific point mentioned by GHJ. They seem to argue in their next to last paragraph that the Engel aggregation problem with double-log functions also constrains income flexibilities to be equal to one. I do not believe that this is so. If the traditional constraints on elasticities are assumed and the system is exhaustive, then all income flexibilities are equal to one no matter what the mathematical structure of the model. This is a direct consequence of the homogeneity condition among price and income elasticities [3, p. 228]. The Engel condition is not the culprit nor is the double-log formulation. This result is the basis for my opinion that income flexibilities are not to be considered as behavioral parameters in the same sense as income elasticities. "That this is an excellent observation of impeccable wisdom, everyone will agree" [5, p. 17].

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References

[1] BENDER, F. E., AND R. E. SUTTOR, "A Look at Flexibilities and Elasticities: Comment," *J. Farm Econ.* 48: 1021–1022, Nov. 1966.

[2] GEORGE, P. S., AND G. A. KING, *Consumer Demand for Food Commodities in the United States with Projections for 1980*, Giannini Foundation Monograph 26, University of California, Berkeley, March 1971.

[3] HOUCK, J. P., "A Look at Flexibilities and Elasticities," *J. Farm Econ.* 48:225–232, May 1966.

[4] ———, "A Look at Flexibilities and Elasticities: Reply," *J. Farm Econ.* 48:1022–1023, Nov. 1966.

[5] WOODWARD, W. E., *Meet General Grant*, New York, H. Liveright, 1928.

[6] YOSHIHARA, K., "Demand Functions: An Application to the Japanese Expenditure Pattern," *Econometrica* 37:257–274, April 1969.

MEASUREMENT OF LEAKAGE BY THE USE OF AN INPUT-OUTPUT MODEL: COMMENT

In the November 1968 issue of this *Journal* [1] Little and Doeksen presented a methodology for estimating leakage coefficients. I will attempt to demonstrate that the methodology does not yield results which conform to their definition of leakage, and to provide an extension of Martin and Carter's methodology [3, p. 14] which does.

Little and Doeksen develop two models—an original model and a modified model with the assumption of no imports. The difference between the multipliers derived from two models is the leakage coefficient, according to Little and Doeksen. The interdependence coefficients matrix for the original model is $(I-A)^{-1}$ where A is the regional technical coefficients matrix. The interdependence coefficient matrix for the modified model is $[I-(A+B)]^{-1}$ where B is the technical coefficients matrix for imports. The element b_{kj} of the matrix B is defined as M_{kj}/x_j where M_{kj} is the amount of imports required from sector k outside the region by sector j, and x_j is the output of sector j. If $L=[I-(A+B)]^{-1}-(I-A)^{-1}$, then, according to Little and Doeksen, the matrix L shows the direct and indirect requirement for imports by different sectors. The totals of each column of the matrix L represent Little and Doeksen's leakage coefficients.

Little and Doeksen define leakage as "... the dampening of the multiplier effect resulting from the import of goods and services and the export of funds to pay for these" [1, p. 922]. The authors define leakage in a related publication [2, p. 17] as "... the net amount of the change in total output which is obtained outside the state as a result of the one dollar change in final demand." The leakage coefficient as derived by Little and Doeksen's procedure does not represent only "the net amount of the change in total output which is obtained outside the state as a result of the one dollar change in final demand." It does represent what could have been obtained in the economy by halting imports. In that sense, it is "the dampening of the multiplier effect." It is not, however, actually the "effect resulting from imports of goods and services and the export of funds to pay for these."

What could have been obtained in the economy by halting imports consists of the "effect resulting from the imports of goods and services and export of funds to pay for these" and an additional interaction of imports and original interindustry flows. This "additional interaction" should not be reflected in the leakage coefficients in order to maintain conformity between the definition and the methodology. The actual direct and indirect import requirement per dollar expansion of final demand which conforms to Little and Doeksen's definition of leakage is shown in the following methodology.

If the functional relationship between import requirements and output is specified, total import requirements may be computed for a specified final demand. For simplicity, the relationship of import requirement and output is assumed as

$$M_{kj}=b_{kj}x_j$$

where

M_{kj} = amount of imports required from sector k outside the region by sector j,
x_j = output of sector j,

and

b_{kj} = a constant.

Let

M_k = total import requirement from sector k:

$$M_k=\sum_{j=1}^{n}M_{kj}=\sum_{j=1}^{n}b_{kj}x_j,\qquad k=1,2,\cdots,m$$
$$=b_{k1}x_1+b_{k2}x_2+\cdots+b_{kn}x_n.$$

Rewriting the system of equations,

$$\begin{aligned}M_1&=b_{11}x_1+b_{12}x_2+\cdots+b_{1n}x_n\\ M_2&=b_{21}x_1+b_{22}x_2+\cdots+b_{2n}x_n\\ &\vdots\\ M_n&=b_{n1}x_1+b_{n2}x_2+\cdots+b_{nn}x_n\end{aligned}$$

or, in matrix notation,

$$M=Bx. \tag{1}$$

The fundamental equation of an input-output model is

$$x=(I-A)^{-1}Y, \tag{2}$$

where A is the regional technical coefficients matrix and Y is the final demand vector. Therefore, substituting (2) in (1), we have

$$M=B(I-A)^{-1}Y=PY\quad\text{where}\quad P=B(I-A)^{-1}.$$

The matrix P shows the direct and indirect import requirement for different sectors. Let P_{kj} be an element of the matrix P. Then, for every dollar's worth of final demand for the output of sector j, P_{kj} units of output are imported from the sector k directly by sector j and indirectly through requirements induced in other sectors of the economy.

Let $P_{.j}$ be the sum of the jth column of the matrix P. Then $P_{.j}$ is the total import requirement for the economy per unit increase in final demand in sector j. This total import requirement consists of direct requirement by sector j and indirect requirement through induced change in other sectors of the economy. Therefore, $P_{.j}$'s actually measure "... the net amount of the change in total output which is obtained outside the state as a result of the one dollar change in final demand" and "... the dampening of the multiplier effect resulting from the import of goods and services and the export of funds to pay for these." In sum, my contention is that the matrix P is the appropriate matrix to measure leakage instead of Little and Doeksen's matrix L.

It is possible to show that Little and Doeksen's procedure provides upward biased leakage coefficients. This can be shown by expanding the matrices P and L by power series expansion [4, p. 144].

$$\begin{aligned}P&=B(I-A)^{-1}\\ &=BI+BA+BA^2+BA^3+\cdots\cdots\infty\\ L&=[I-(A+B)]^{-1}-(I-A)^{-1}\cdots\cdots\infty\\ &=I+(A+B)+(A+B)^2+(A+B)^3\cdots\cdots\infty\\ &\quad-I-A-A^2-A^3\cdots\cdots\infty\end{aligned}$$

$$
\begin{aligned}
&= I+(A+B)+(A^2+B^2+AB+BA)+(A^3+AB^2+A^2B) \\
&\quad +(ABA+BA^2+B^3+BAB+B^2A)+\dots\dots\dots\dots\infty \\
&\quad -I-A-A^2-A^3\dots\dots\dots\dots\infty \\
&= B+B^2+B^3+\dots\dots\dots\dots\infty \\
&\quad +AB+BA+AB^2+A^2B+ABA+BA^2+BAB \\
&\quad +B^2A\dots\dots\dots\dots\infty \\
&= B+BA+BA^2+\dots\dots\dots\dots\infty \\
&\quad +B^2+B^3+\dots\dots\dots\dots\infty \\
&\quad +AB+AB^2+A^2B+ABA+BAB+B^2A+\dots\dots\infty
\end{aligned}
$$

and $L>P$, provided B is a non-null matrix,[1] and Little and Doeksen's leakage coefficients are biased upward.

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[1] Where B is null matrix, there is no import in the economy, and the question of leakage does not arise.

References

[1] LITTLE, CHARLES H., AND GERALD A. DOEKSEN, "Measurement of Leakage by the Use of an Input-Output Model," *Am. J. Agr. Econ.* 50:921–934, Nov. 1968.

[2] ———, *An Input-Output Analysis of Oklahoma Economy*, Oklahoma Agr. Exp. Sta. Tech. Bull. T-124, Feb. 1968.

[3] MARTIN, WILLIAM E., AND HAROLD O. CARTER, *A California Interindustry Analysis Emphasizing Agriculture—Part I: The Input-Output Models and Results*, Giannini Foundation Res. Rep. 250, University of California, Feb. 1962.

[4] MIERNYK, WILLIAM H., *The Elements of Input-Output Analysis*, New York, Random House, May 1967.

MEASUREMENT OF LEAKAGE BY THE USE OF AN INPUT-OUTPUT MODEL: REPLY

In the article [1, p. 922] we defined leakage as "... the dampening of the multiplier effect resulting from the import of goods and services and the export of funds to pay for these." This definition is used in the article and is consistent with the methodology. Mr. Mustafa agrees with this in his third paragraph where he states, "It does represent what could have been obtained in the economy by halting imports. In this sense, it is the dampening of the multiplier effect." Then, in the fourth paragraph, Mr. Mustafa states what could have been obtained by halting imports. His discussion of additional interaction was included in our definition of leakage and in our methodology.

The confusion arises when Mr. Mustafa takes our definition of *output leakage* from another publication [2, p. 17] which he states as "the net amount of the change total output which is obtained outside the state as a result of the one dollar change in final demand." The definition in this article should not be taken out of context as it refers to an application of the leakage methodology. The import matrix is a net import matrix, since the data were available only in this fashion. If the import matrix could have been available on a gross basis, the leakage definitions related to output, income, and employment would have been stated differently and confusion would not have resulted.

In summary, the definition we used includes the "additional interaction" which Mr. Mustafa discusses. However, our methodology also includes this measure. Thus, our definition and methodology are consistent and our coefficients are not biased upward.

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References

[1] LITTLE, CHARLES H., AND GERALD A. DOEKSEN, "Measurement of Leakage by the Use of an Input-Output Model," *Am. J. Agr. Econ.* 50:921–934, Nov. 1968.

[2] ———, *An Input-Output Analysis of Oklahoma Economy*, Oklahoma Agr. Exp. Sta. Tech. Bull. T-124, Feb. 1968.

Reviews are listed alphabetically by authors.

Book Reviews

Balassa, Bela (and associates), *The Structure of Protection in Developing Countries*, Baltimore, The Johns Hopkins Press, 1971, xviii + 375 pp. ($12.00)

This volume contains the results of a research project on the structure of protection in developing countries. The project was under the direction of Bela Balassa and was based on a number of country studies, i.e. Brazil (Joel Bergsman and Pedro Malan), Chile (Teresa Jeanneret), Mexico (Gerardo Bueno), West Malaysia and the Philippines (John Power assisted by Cristina Crisostomo and Eloisa Litonjua), Pakistan (Stephen Lewis and Stephen Guisinger), and finally Norway (Bela Balassa and Preben Munthe), selected for the sake of comparing the structure of protection in a developed country to that prevailing in developing countries.

All the country studies followed the same methodology which made it possible for Bela Balassa to undertake a rigorous and valuable comparative analysis contained in the first five chapters of the book. The first chapter provides, in a concise and clear way, the underlying methodology of effective protection and procedures for measuring it. Chapter 2 reviews the patterns of economic structure, growth, and trade of the seven countries in the sample. Chapter 3 is devoted to an examination of nominal and effective protection in these countries, while Chapters 4 and 5 attempt, respectively, to evaluate the system of protection and to offer guidelines for industrial protection policy. The next seven chapters contain the above-referred country studies. Finally, the volume ends with a series of technical appendices.

This is a valuable book which throws light on the important question of the consequences of protection on efficiency within a general equilibrium framework. It postulates a rigorous and uniform methodology which is applied to each of the countries. The uneven quality and availability of information in the seven countries surveyed required the authors, in a substantial number of cases, to modify the theoretical framework and make relatively arbitrary assumptions. This is perhaps an unavoidable process in an empirical study and reflects the scarcity of data which conform and correspond to the theoretical requirements of the analysis.

A comparison of the structure of protection in the seven countries under consideration reveals considerable variation in the extent of net protection of domestic manufactured goods. The latter are highly protected in Pakistan, Brazil and Chile, less so in the Philippines, only slightly in Mexico, and not at all in Norway and Malaysia. In the first five countries agriculture and primary activities, in general, are strongly discriminated against, while in the latter two agriculture is protected and energy and mining are discriminated against. Within the manufacturing sector there is much similarity in the interindustry pattern of protection. Unfortunately, since most agricultural activities are consolidated together, it is not possible to judge the extent of variations in the degree of discrimination as between specific agricultural products. This is one area in which further work appears called for—particularly since many recent input-output tables of developing countries contain a fairly high level of disaggregation of the agricultural sector.

In fact, in Pakistan, Brazil, Chile, and the Philippines the burden of industrialization was shouldered almost completely by agriculture through policies which turned the internal terms-of-trade heavily against the latter sector. The efficiency and resource cost of such policies is clearly revealed by cases of negative value added (at world prices) and stagnation of agricultural production in these four countries, while in contrast per capita food production rose rapidly in Mexico and Malaysia during the postwar period. There is evidence that many developing countries have learned their lesson and are abandoning "industrialization-first" strategies in favor of more balanced strategies relying on widespread agricultural development consistent with a process of economic and social development aimed at a combination of economic growth, increased employment, and a more equal income distribution. In this connection, one possible shortcoming of this study is the fact that it does not analyze the effects of the protectionist policies on objectives other than economic efficiency and, more particularly, on employment and income distribution. It appears likely that these policies have had an undesirable impact on employment and contributed to a more unequal income distribution. Perhaps, in some cases, a trade-off between the latter objectives and economic growth—at least in the short-run—might have been identified.

In conclusion, this is an important addition to the literature on trade and development and should be required reading for anybody interested in the effects of protection.

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Bronfenbrenner, Martin, *Income Distribution Theory,* Chicago, Aldine · Atherton, Inc., 1971, xiii + 487 pp. ($14.75)

Professor Bronfenbrenner calls his book "an old-fashioned income distribution book," meaning that he attempts a reformulation and restatement of income distribution along the lines of the neoclassical economic theory. The issues involved are complex and still unsettled. The book offers a fair presentation of the opposing views on the various issues although there is discernible decline in the writer's enthusiasm when he discusses the critics of neoclassical theory. For example, the problem of valuing capital as an economic aggregate is discussed and disposed of in exactly eight lines (p. 397). The book is written at the graduate level and utilizes effectively verbal, geometric, and algebraic exposition. Its wide coverage also makes it useful as a reference book. Unlike many other books of comparable rigor, this one is written in a stimulating way with occasional tastefully humorous remarks.

In the first five chapters Professor Bronfenbrenner establishes the importance of income distribution and presents some statistics relating to personal and functional distributions. The exposition has motivating force, a *sine qua non* condition for a good textbook. An obvious imbalance occurs in Chapter 4, where a lot of space is taken up by Lorenz curves, concentration ratios, and various statistics, while some of Marx's ideas are covered in a footnote (p. 88). Knowing Professor Bronfenbrenner's scientific objectivity, one cannot but wonder why. The neoclassical theory of income distribution at the microeconomic level is presented in Chapters 6 to 10, with all of Chapter 7 devoted to the "antimarginalist backlash." The macro-distribution is discussed in two chapters (11 and 16). Chapters 12 to 15 treat interest, rate, rent, and profits theories. The last chapter (17) discusses guidelines, guideposts, and income policies in a pragmatic manner.

The list of references is complete with the exception of Bhaduri's paper [1] which apparently appeared too late to be discussed or referred to in the book.

Professor Bronfenbrenner has presented the neoclassical position adequately, clearly, and carefully. But it is still a "story for the faithful." The main theoretical questions still remain. Is neoclassical theory appropriate for the explanation of distribution? Is there an aggregate production function? Can we evaluate capital independently of the rate of interest so that we avoid circular reasoning? The issues involved are still unsettled, and they have recently been discussed by Ferguson and Nell [2] on the occasion of publication of Bronfenbrenner's and Pen's books [3]. This reviewer can offer no better commentary than those of Ferguson and Nell, to whom the reader is referred.

In conclusion, for this reviewer's tastes this is the best book available on income distribution theory. Its publication will accelerate the commencing revival of distribution economics.

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References

[1] Bhaduri, A., "On the Significance of Recent Controversies on Capital Theory: A Marxian View," *Econ. J.* 79:532–539, Sept. 1969.

[2] Ferguson, C. E., and E. J. Nell, "Two Review Articles on Two Books on the Theory of Income Distribution," *J. Econ. Lit.* 10:437–453, June 1972.

[3] Pen, Jan, *Income Distribution,* London, Allen Lane, 1971.

Buchanan, James M., and Robert D. Tollison, eds., *Theory of Public Choice,* Ann Arbor, University of Michigan Press, 1972, vi + 329 pp. ($15.00)

Most of the papers in this collection relate to Buchanan's argument for "closed" systems of behavioral analysis: systems taking into account a person's voting behavior as well as his market behavior. The general argument is presented in two papers by Buchanan, and also in Tollison's introduction. With one exception noted below, voting is assumed to be selfish.

Eighteen of the twenty-three papers are reprinted. (The date of original publication is shown in parentheses when a reprinted paper is referred to below.) Not all the papers are discussed below.

Papers integrating market and political behavior will be mentioned first; most of the papers pertain to political behavior alone or have only minor treatment of the relation of market behavior to political behavior. The most interesting of these papers is Buchanan's treatment (1968) of multi-part public utility pricing, on the basis of the voters' assumed reactions to subsidizing buyers of utility services, assuming decreasing cost. Charles J. Goetz (1964) ingeniously analyzes the seriousness of the index number problem arising when taxes change relative prices of private goods and so change the weights used in defining a composite private good used conceptually in evaluating allocation of resources between public and private sectors. David B. Johnson-Mark V. Pauly (1969) deal with resource misallocation under Wicksellian voluntary finance, when "inefficient" taxes must be used in place of lump-sum taxes. The fact that the Wicksell system seems infeasible limits the significance of this resourceful discussion.

Interactions between parents and voters are examined by William Craig Stubblebine (1965) and Pauly (1967). Stubblebine assumes that the political unit has already decided to maximize total expenditure on education, and concludes that in terms of probable outcomes, a combination of public and private schools will be efficient. His choice of basic assumption seems questionable. Selecting total expenditure is interdependent with choosing methods of finance; in any case, maximizing total expenditure on education probably would not be accepted as an objective by the voters. Moreover, the private-public combination he refers to may run counter to the voters' interest in discouraging private education tending to increase expenditure on the education of the rich.

Pauly's work on education seems less valuable than Stubblebine's. Pauly assumes that the society has determined a quantity of education to be provided to each child. Then families are assumed to state (without strategic behavior) the amounts of educational expenditure they will undertake, given each of a series of public expenditure figures. Each family is charged the maximum feasible fraction of the predetermined constant total expenditure per child. This procedure is analogous to one in which a discriminating monopolist would trick his customers into giving him information needed to maximize his profit. Fortunately, Pauly's system is not likely to be approximated in practice.

Buchanan (1965) and Cotton M. Lindsay (1969) deal with free national health services. Using his assumption of selfish voting, Buchanan finds a contradiction between a person's behavior as a customer demanding free service and his behavior as a voter providing the service. Lindsay assumes that a desire to promote equality is significant in relation to these services and deals with the cost of waiting in line as the social cost of promoting equality. Comparison of these two papers underscores the dangers involved in rigidly assuming selfish voting.

Topics to be considered in papers on political behavior are (a) ways of reducing conflicts among voters, (b) possible political action undertaken because the corresponding private group action would be inconvenient, (c) unavoidable conflicts among groups of voters within one political unit, and (d) relations among political units.

Buchanan argues reasonably that earmarking taxes enables the voters to arrive at the "median" expenditure on each public good, avoiding the conflict occasioned (under general-fund financing) by the necessity for determining a mix of public goods. The more elaborate treatment of the earmarking procedure by Goetz (1968) is interesting, but illustrates the difficulties associated with unwise choice of assumptions about voting. Goetz assumes that the voters conduct separate referenda on the ratio between amounts of money to be spent on two public goods and the total amount of money to be spent on the two goods. This assumption appears to correspond to no political reality and weakens his analysis.

Buchanan-Gordon Tullock (1968) suggest that the political unit may create gain for a monopolist's customers by organizing a system for compensating the monopolist for foregoing use of his monopoly power. (Presumably it would be inconvenient for the customers to organize such a system.) Since future customers will benefit by elimination of the monopoly action, present shareholders in the monopoly might be compensated by receiving the proceeds of the sale of public securities. This is a seminal paper deserving serious consideration in relation to public policy.

Most of the papers elucidating unavoidable conflicts between groups of voters are straightforward, and for the most part lead to predictable results.

Two of these papers, however, appear to exaggerate the seriousness of the conflicts they deal with. Buchanan-Pauly (1970) cast doubt on the proposition that tax deductions benefit the taxpayers able to use them; they point out that creating the tax deduction will create a need for higher tax rates and that a person who saves money through using the deduction may lose a greater amount of money by paying higher tax rates. This seems only to suggest that alternative tax plans should be completely specified and that the effects of individual tax provisions cannot be discussed sensibly in isolation.

Buchanan (1967) discusses the fact that the voters' attempts to use tax reductions and expenditure increases to reduce aggregate instability will be partly vitiated by their attitudes toward the public goods that are the objects of government expenditures. But here we have only the usual need for weighting of objectives in choosing among social actions; it would be irrational for the voters to choose an action as though stability were the only significant social objective.

In connection with relations among political units, Goetz-Charles R. McKnew, Jr. demonstrate conditions under which an unconditional grant will be relatively effective (in comparison with a matching grant of the same size) in stimulating total public expenditure on a selected public good. The analysis depends upon the same unfortunate "referenda" assumption referred to above in connection with Goetz's paper on earmarked taxes.

Finally, Tullock proposes a division of labor among social scientists: the domains of work would be study of choice and study of preference (including study of factors molding preferences.) The necessity for Tullock's distinction is compelling, but its implications for academic organization are less clear than Tullock suggests.

The volume helps the reader appreciate the cogency and practical importance of Buchanan's argument for a closed behavioral system of analysis. Unquestionably economists have usually made the gratuitous assumption that social choice is made as though voters voted on alternative general principles, without knowing how the general principles would affect them in relation to a specific action choice.

The difficulties involved in integration are suggested by the fact that except for Buchanan's treatment of public utility pricing, there are no significant substantive achievements in integration.

In relation to political action, the best contributions (Buchanan on earmarking taxes, Buchanan-Tullock on compensation for monopolists) increase the flexibility of action available to voters and consumers. Use of unrealistic assumptions appears to be the most serious weakness in the least satisfying papers.

The assumption of selfish voting is at worst a valuable counter-irritant in relation to the usual selfless assumption. But assuming selfish voting seems imprudent in relation to national health service and military expenditures.

The volume is valuable partly for its substantive results, but perhaps still more for its demonstration of the need for further work in the areas examined.

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Di Marco, Luis Eugenio, ed., *International Economics and Development*, New York, Academic Press, Inc., 1972, xix + 515 pp. ($18.50)

This book is a collection of 23 essays that are generally unpublished elsewhere. It aims at two purposes: (1) "to bring together the main lines of development" in the vast field of international economics; and (2) to "honor the many contributions of Professor Raul Prebisch to international economics," both by retracing the main dimensions of his economic thought and social doctrine, and by evidencing their impact on the economic profession and on policy making. Designed as an *ex ante* selection of authors who were asked to "contribute articles covering their most recent work, with emphasis wherever possible on the connections with Prebisch's own work over the years," it achieves neither one of these two ambitious goals fully. The essays collected are highly heterogeneous—in fields of interest, approaches, ideologies, and geographical concerns—and are not structured at giving a comprehensive coverage of the field. Neither are the outstanding contributions of Raul Prebisch systematically evidenced, in part because of the bias towards orthodoxy in the selection of authors, with a few notable expections, when the major role of Raul Prebisch may have been to induce the need for a reconsideration of the neoclassical theory of transmitted growth through international trade relations. While a number of papers are rather thin (making one wish that they had benefited of the standard journal article review process instead of receiving on-faith book treatment), the book contains a number of excellent contributions, including several by foreign economists not currently read in English language professional journals, that will make it a must to have for most libraries.

Three essays are directly concerned with an analysis of Prebisch's work. Di Marco reviews the elements of the "Prebisch thesis" of center-periphery relations, of deteriorating terms of trade and unequal distribution of welfare gains from commercial exchange, and the consequent three successive stages in Prebisch's policy recommendations at ECLA: industrialization through import substitution, economic integration in the ALALC, and international assistance through preferential trade agreements for less developed countries. The papers by Di Marco and Dadone, and by Cornejo retrace the impact of Prebisch's thought on modern economic analysis and the nature of his social doctrine. These papers are rather faithful accounts of Prebisch's work but in general fail to bring out what I consider to be his most outstanding contribution: that of a challenger of the established monetarist doctrines in international economics and of a key contributor to the development of the structuralist and later socialist economic schools in Latin America. Perhaps one of the best eulogies of Prebisch's contributions is, in that sense, given by de Bernis' paper on industrialization policies for less developed countries; this capitalizes on Prebisch's findings to discuss pragmatically how the agricultural surplus should be captured and invested in "industrializing industries" to construct a coherent industrial structure.

Other essays that relate closely to Prebisch's work are the description by Pinto and Kñakal of the way in which the center-periphery relations have evolved over the last twenty years with the increasing center-periphery polarization, a differentiation of the capitalist center due to the relative loss of hegemony of the United States, and the rise of a socialist center; Bela Balassa's analysis of the policies that have permitted Taiwan and Korea to evolve successfully from "inward-looking" import substitution industrialization to "outward-looking" export oriented development; Fishlow's historical description of the origins and consequences of import substitution in Brazil; and Chipman's attempt at developing a theory of exploitative trade and investment that could provide a basis for policy making in the periphery.

Many readers will likely find extremely useful Arthur Lewis's reflections, 14 years after his original paper, on unlimited supply of labor. The article clarifies a number of misconceptions on the essential elements of the classical dual economy model, in particular on the importance of the zero marginal productivity of labor assumption versus the one of the existence of an excess supply of labor. It also recapitulates much of the controversies around the empirical evidence on excess labor supply and on the existence of turning points. For a few specialists of trade theory, the theoretical exercises of Amano on stability conditions and of Kemp on foreign exchange may also prove useful.

Some of the thinner papers in the book are Zarembka's three sector model of economic growth that is neither estimated nor developed analytically; Myrdal's discussion on twisted terminologies like the words United Nations and developing countries; Elias' identification of the role of foreign trade as a source of growth in Argentina; and Bhagwati, and Cheh's empirical analysis of the place of exports in normal patterns of growth.

The remnant papers constitute interesting contributions in a variety of disparate fields: Tinbergen briefly outlines the significance of non-treadable industries for national planning; Corden exhaustively identifies the dimensions of the relation between protection and growth; Dagum develops a stochastic model of the functional distribution of income; Ffrench-Davis and Arancibia discuss the potential roles of foreign capital versus domestic savings in Latin American development; Kindleberger presents different ways of calculating the returns from investment in primary product industries in less developed countries for the different parties involved; Letiche describes the basic conditions and objectives of African economic development; Powelson recommends to Latin American countries to adopt a policy of strength for successful negotiation with the United States; and Harry Johnson criticizes devastatingly the Pearson *Partners in Development* report for having failed to provide a new motivation for the giving of development assistance.

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Dorner, Peter, *Land Reform and Economic Development*, Baltimore, Penguin Books, Inc., 1972, 167 pp. ($2.75 paper)

This volume is one of a series of economics texts designed for students of economics in universities and colleges. It is well written and should serve as interesting reading for the layman as well as the undergraduate university student. The book is oriented toward, but not limited to, the low-income countries of Asia, Africa, and Latin America.

In "The Role of Land Reform in Development Strategy" (Ch. 1) land reform is identified as an important element in the process of institutional change as related to the redistribution of economic and political power. (One might add the matter of social status and mobility among social classes to the role of land reform.) Land tenure conditions are linked to the "third generation" problems of rural employment and income distribution that have accompanied the "'green revolution." The main obstacles to land reform are political and social structures, not a lack of knowledge of the economics of land tenure.

Chapter 2 is a very succinct summary of the diversity in tenure conditions, issues, and approaches to reform around the world—with emphasis on Latin America, Africa, and Asia.

The next three chapters evaluate land reform in terms of developmental consequences—first, as a means of realigning income, and economic, social, and political power; second, as a means of increasing rural employment; and third, as a means of increasing agricultural output. The theoretical arguments are linked with a wide geographic range of empirical examples.

The final chapter draws rather heavily from the author's article, "Needed Redirections in Economic Analysis for Agricultural Development Policy," which appeared in the February 1971 issue of this *Journal* (pp. 8–16). The international agencies are urged to play a stronger and more positive role. It is argued that, in program analysis, consideration should include the creation of secure opportunities on the land, the development of human abilities and capacities, and the inclusion of income distribution as an explicit variable. Where extensive land redistribution is not feasible, the intensification of programs to support the peasants is recommended.

For persons interested in "land reform" or "agrarian reform," this is a good text with which to begin. A set of approximately 155 references is given and would provide sources for further study.

The author argues that land reform should be among the central issues of concern to our profession. My personal opinion as to why it has not been there in the past is in large part due to the unfortunate institutional and theoretical dichotomy that developed a number of years ago. The (oversimplified) implication was that there were no theories with respect to institutions and no institutions in theories. As pointed out by the author, much of the economic theory has taken the institutional system as given—not something to be *explained* or *determined*. More work on the theories of institutional structure and change is needed in order to understand better and deal effectively with questions of institutional development. For example, what happens when a private enterprise system is super-imposed on a "'feudalistic" socio-political structure in comparison with a broad-based property and socio-political structure? Also, what happens when education and some of the other services are not socialized in a private enterprise system? Is it possible, without passing through a period of extreme chaos, to move from a rigid system, with discipline imposed from above, to a more flexible one that is responsive to the masses?

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Freeman III, A. Myrick, Robert H. Haveman, and Allen V. Kneese, *The Economics of Environmental Policy*, New York, John Wiley & Sons, Inc., 1973, xii + 184 pp. ($6.95 cloth, $3.95 paper)

Krutilla, John V., ed., *Natural Environments: Studies in Theoretical and Applied Analysis*, Baltimore, The Johns Hopkins University Press for Resources for the Future, Inc., 1972, viii + 352 pp. ($16.50)

Natural resources and environmental economists have long since learned to monitor continually the outputs of professionals associated with Resources for the Future, Inc., for valuable publications supportive of our teaching and research activities. These two recent contributions represent the two extremes of the wide spectrum of types of publications which we have come to expect from the RFF staff and their associates. The first is a cogent summarization of recent contributions of the three co-authors, and others, emphasizing materials balance and the interconnectedness of the environment and the economy. As such it is ideally suited for classroom use and is a valuable contribution to undergraduate teaching programs. The second is at the other extreme. It is a collection of research papers designed to identify the state of the arts and, one supposes, to foster further research interests in the increasingly challenging and important areas of allocative decision-making and management of natural environments. As engendered activity increases, we would expect the culmination of this and future activity in a treatise, parallel to the first book under review, perhaps titled, *The Economics of Natural Environments.* The dissimilarity of the two, both in level and subject matter content, necessitates the separate reviews below.

The authors of *The Economics of Environmental Policy* produced a well organized book which will lessen the "'cut and paste" operations forced upon instructors in order to synthesize the past decade's flow of information about environmental quality and materials balance for classroom use. It is admirably suited for undergraduate instruction and is a good pre-reader for graduate students seeking entry-level perceptions of problems and policy alternatives. The book ". . . presupposes no prior background in either economics or the natural sciences" (p. vi), and there is a bit for everyone—economist, political, biological, and natural scientist. None will feel that their expertise is slighted as the authors take great care in identifying across the range of reader interests, the nature of environmental quality problems, and the need for better information, jointly-produced and -utilized, necessary to attain the objective of better environmental management.

The organization of the book makes it attractive for a variety of courses; instructors may use the entire book or assign rather well-compartmentalized chapters to meet course needs. In the introductory chapter, the authors identify sources of concern about environmental quality and pose economic questions about four current policy issues—automotive emission standards, the sulfur oxides tax, federal sewage treatment grants, and zero population growth. Chapter 2 ("The Environment and the Economy") lays out the materials balance model, identifies possible technological options for reducing through-put, and concludes with an elementary discussion of the economics of pollution control. Physical and technical aspects of different pollutants are discussed in the third chapter. The Havemanian description of the market system and the causes of market failures for environmental goods and services —common property and public goods characteristics —follow in Chapter 4 ("The Market System and Pollution"). In "The Economic Principles of Pollution Control" (Chapter 5), a pollution control model, based on benefit and cost functions, determines socially-optimum levels of pollution control. Alternative control strategies are evaluated, yielding the conclusion that a residuals charge strategy is preferred. The next two chapters examine current public policies for water and air pollution control and conclude that present subsidy- and/or standards-oriented programs are not as cost-effective as possible alternatives adopting economic incentives. The two concluding chapters discuss broader issues including distributions of benefits and costs, the ZPG-economic growth-environment interface, and institutional and political requirements for effective pollution control.

One cannot easily criticize the contents of the book, since the substance of what is written has been largely accepted by the profession. I would have preferred to have seen some expansion of the importance of transaction costs in the market failure model of Chapter 4 and in the optimum pollution control model of Chapter 5, but such minor choices of emphasis can be easily embellished by the instructor. Whether instructors use only the "heart of the authors' message," Chapters 2, 4, and 5, or more, the merits and utility of this book (including its availability in paperback) should lead to widespread classroom adoption.

The second book contains nine papers presented at a RFF Workshop which ". . . represent a cross-section of current progress in Resources for the Future's natural environments program and by associated researchers." The discipline origins are diverse; five papers are authored by economists, and one each by a geographer, zoologist, landscape architect, and psychologist. Therefore, most readers will be interested in only selected papers within the volume, depending on their research interests. And, since the works are generally valid contributions at the "frontier of knowledge," it is most difficult to treat each comprehensively for readers of this review. In fact, the editor (Krutilla) utilizes most of the 17-page introduction to brief the papers, a valuable service to those whose research interests are in the area.

Of most interest to this reviewer are the very interesting first two papers by Fisher, Krutilla, and Cicchetti ("Alternative Uses of Natural Environments: The Economics of Environmental Modification") and by V. Kerry Smith ("The Effects of

Technological Change on Different Uses of Environmental Resources"); and papers by Fisher and Krutilla ("Determination of Optimal Capacity of Resource-Based Recreation Facilities") and by Brown and Hammack ("A Preliminary Investigation of the Economics of Migratory Waterfowl"). In the first paper, the authors develop a model for allocating natural environments between preservation and development. They make empirical estimates for Hells Canyon and enhance their presentation with ranges of outcomes due to varying parameter values. The resulting model yields the conclusion that in view of decreasing benefits from development relative to benefits from preservation and the impossibility of "undevelopment" (irreversibility), Hells Canyon is likely to yield greater benefits if left in its natural state. In the second paper, Smith, working in a theoretical general equilibrium framework, shows that technological advances in consumer goods production will yield relative price increases for amenity services in all but peculiar cases. Thus, while the framework of analysis differs somewhat from the first paper, it is a contribution to the same theme, i.e., increasing relative prices for amenity services should be incorporated into preservation versus development decisions where irreversibilities are real. In the Fisher and Krutilla paper, the authors develop economic models for the benefits and costs for low-density, wilderness recreation incorporating congestion costs. Encouraged by the findings of Stankey ("A Strategy for the Definition and Management of Wilderness Quality") regarding preferences of wilderness users, the authors suggest a comprehensive simulation study with willingness-to-pay functions for levels of intensity of use.

The Brown and Hammack contribution is, perhaps, the most exciting in terms of its development in a less well-hiked area of inquiry than those cited above. It develops an analytical framework and makes an initial empirical thrust for inferring the value of wetlands important in the production of a common property, fugitive resource (ducks) when those lands have some development value in agricultural (private good) production, if drained. Willingness-to-pay demand models for hunters and production models for ducks are used to form the basis of the allocative decision. The need for better research information, particularly from biologists, on the production side, is an acknowledged need but while the results are not yet sufficient for policy-making implications, the approach should attract the interest of researchers concerned with other fugitive, biological resources.

The remaining papers by Shelton ("A Quantitative Approach to the Classification of Inland Waters"), Litton ("Aesthetic Dimensions of the Landscape"), and Chaik ("Appraising the Objectivity of Landscape Dimensions") are not immediately of interest to economists, although the first contains quantitative methodology which may be of applied interest in other problem settings and the latter two may yield information useful to variable definitions for economic analyses requiring quality shifters in quantitative models. We will look forward to the review of *The Economics of Natural Resources*, by the end of this decade, hopefully. It is off to an exciting start.

WARREN E. JOHNSTON
University of California, Davis

Heady, Earl O., Leo V. Mayer, and Howard C. Madsen, *Future Farm Programs: Comparative Costs and Consequences*, Ames, The Iowa State University Press, 1972, viii + 411 pp. ($11.95)

The 144-region production and transport model for the United States developed at Iowa has been used to estimate the effects of about 30 potential land control programs. In the simulated market for cropland, land which cannot earn a positive rent goes out of production as does land taken out by program measures. Cropland capacity, assumed to be equal to 1965 harvested cropland plus land declared diverted by recent programs, is sufficient to meet 1980 domestic demand and increase major crop exports two to three times. The prices per bushel required for capacity production are $4.40 for wheat, $2.53 for corn, and $6.19 for soybeans. If exports remain at their 1965 level, total demand can be met with a third of the cropland capacity idled and with free market prices of $1.11 for wheat, $.69 for corn, and $1.13 for soybeans.

The total acreage results are similar to those reported from predecessor models at Iowa. The high prices required for capacity production have received less attention. Price changes are determined in the model by differences in production costs among regions and lead to great variations in unconstrained supply responses. Some regions have stable acreage, while others are highly sensitive. The relative cost disadvantage of much of North and South Dakota is reflected in their coming out of production under free market conditions and several of the program alternatives. The Southeast continues to decline apparently regardless of what assumptions are made. Smaller marginal areas throughout the country can be identified from the maps.

To evaluate the results fully would require checking the budget data used to estimate costs for the crops in each subregion. Price elastic land conversions to idle, pasture, and woodland are not included in the model, since the decision whether to farm the crops depends on the all or nothing condition of whether a positive rent can be earned. Cropland responses to price within regions before zero total rent is reached would make the supply of agricultural products as a whole more elastic and would reduce the predicted changes in long run prices associated with different demand conditions. Similar comments can be made about responses not allowed for of purchased inputs, capital, and labor use to changes in product prices. A hypothesis is that the general pattern of acreage adjustments among regions would not be too much affected by these considerations, but a substantially greater long run price elasticity of supply of agricultural products could be found.

Many of the program variants analyzed reflect regional goals preventing full adjustments in areas indicated to be marginal from the point of view of minimizing national production and transportation costs. Within the confines of the traditional land control approach, a wide range of alternatives has been analyzed. The results are presented objectively and with reasonable clarity, and they should be valuable in public discussion and technical program design.

A few alternatives to the traditional land control approach are discussed but not seriously quantified in the book. Future volumes, it is hoped, will report applications to a widening range of policies. The public is at least as interested as ever in finding a way out of farm program burdens. Less static control programs deserve to be considered, aiming for a gradual approach to financial self-sufficiency for commercial agriculture allowing production eventually to move to most economical areas. As one possibility, changes in diversion provisions and perhaps salable transfers could provide for gradual regional adjustment neither moving production all at once nor freezing locations. Passing comments are made in the book indicating that the incidence of land control programs is on land values and repeating suggestions for tying payments to people. To trace out the implications seriously in numerical terms could make real the possibilities for people-oriented income approaches to commercial agriculture. Recent events, together with the large influence of international assumptions on the model results reported, bring home the desirability of considering a permanent policy stance toward international variability. A goal could be to reduce export subsidies over a period of years, aiming toward a permanent policy of cushioning domestic agriculture from yearly swings in international prices by basing export prices offered to producers on an average of the international prices of the past five or ten years. This is a propitious time to expand the range of policies analyzed.

The last half of the book includes a highly interesting and separate study exploring policy simulations for farm adjustments. The last half also contains material on structural changes in farming and rural areas, an analysis of export costs, and an econometric study for agriculture at the U. S. level.

G. S. Tolley
The University of Chicago

Machlup, Fritz, Walter S. Salant, and Lorie Tarshis, eds., *International Mobility and Movement of Capital*, New York, Columbia University Press for the National Bureau of Economic Research, Inc., 1972, xi + 708 pp. ($20.00)

This book comprises all papers and comments prepared for the Conference on International Mobility and Movement of Capital held in 1970 under the sponsorship of the University's National Bureau Committee on Economic Research. The 17 major papers that make up the volume cover a wide range of topics on capital flows and contain both a substantial amount of descriptive as well as theoretical materials. Also, comments on each paper are included. Brief abstracts of each paper are presented which the reader should find helpful in selecting particular papers of interest. However, summaries are not given of the comments to each paper. A tabular characterization of the papers is provided, but I would prefer to categorize the papers as follows.

The first category contains the papers by Cohen, Hawkins, and Gillespie. These papers are highly descriptive and deal with international capital movements from the standpoint of European countries. Cohen's main thrust is that once the United Kingdom was a large exporter of capital but now it no longer plays this role; instead, it is an international investment banker and a middleman of funds. Hawkins concludes that, even with the European monetary coordination, unlike what was expected, capital movements among European Common Market countries are not becoming more important than between these countries and the rest of the world. Gillespie's conclusion is that, with respect to England, France, and Germany, each has different policies with regard to direct investment and takeover by foreign firms; also, their policy actions are inconsistent with official statements. Those interested in international capital movement methodology will not find these three papers of particular interest. However, I did find some of the data presented and the conclusions derived quite interesting.

Category 2 contains papers on the determinants of direct investments primarily made by the United States. Most papers contain both a theoretical model and an empirical counterpart. Leamer and Stern conclude that the well-known portfolio approach is appropriate for decisions on portfolio investment but is not suitable for decisions on direct investment. Also, it is difficult to include in empirical work expected returns and risks. Bryant and Hendershott show that frequently one is unable to discriminate clearly in purely statistical terms among alternative specifications of the determinants of international capital flows. Stevens builds a model where the decision of a firm is one of making direct investments abroad and its choice of whether to finance these expenditures at home or abroad. He concludes that the firms may have borrowed more abroad but that they did not reduce direct investments. Severn concludes that the firms' decisions to invest abroad and to raise funds abroad are interrelated with their domestic activities. Prachowny shows that, at least in 1966, the restraint program in the United States had perverse effects on the balance of payments. Reuber and Roseman, on studying international capital flows to

Canada, conclude that these flows are affected very little, if at all, by such factors as aggregate economic growth, economies of scale, research and development, and changes in antitrust laws and their enforcement in the United States. They contend that the foreign takeover is largely explained by the level and pattern of mergers in the United States. Dobell and Wilson conclude that none of the major tax reforms proposed in Canada in 1967 and 1969, if implemented, would have had devastating effects on the balance of payments.

A considerable amount of work has been done on the determinants of direct investment in addition to the papers presented at this conference. Although there are a good many references contained in each paper, many references to good papers in the field are missing. Nevertheless, I recommend these papers to people who are not only working in the area of direct investments but also to those who do empirical analysis in general since many of the comments concerning econometric estimation apply to many areas of research. There are excellent discussions concerning problems of model specification, hypothesis testing, and the like. Also, there are some excellent critiques of these papers presented in the book.

On the topic of direct investment, I would like to see a conference held sometime where many of the panel members consist of real world international entrepreneurs. Many times I feel that academic economists really miss the boat concerning what motivates international firm managers to behave as they do. For example, whether major firms hedge against possible devaluations really is something that, I am convinced, academic economists know very little about.

The following papers deal with capital movements in general. The paper by Floyd on portfolio equilibrium theory of capital movements is highly theoretical and is well done. I recommend this paper to people interested in economic theory. However, there is yet no agreement in the profession as to the validity of such an approach to the study of direct investments.

The paper by Howle on capital mobility and payments equilibrium attempts to explore the nature of the ultimate limits of fiscal policy that are imposed by fixed exchange rates. Also, he demonstrates that perfect mobility of capital makes a specie-flow mechanism inoperative. Again, I would suggest that this paper be read along with the reviewers' comments.

The papers by Miller and Whitman and by Branson and Willet deal specifically with short-term capital flows as opposed to long-term flows and direct investments. The first paper tries to explain the movements of short-term funds by constructing both the supply function of foreign I.O.U.'s to American lenders and the demand function for foreign I.O.U.'s by American lenders. Deviations of the GNP of the United States from its time trend were used as a proxy for risk conditions. These deviations, together with levels of domestic and foreign interest rates, are essential influences on flows of capital. In the other paper, interest rates and trade flows show up as a most significant variable explaining changes in the flow of short-term funds. However, I am sure, as with long-term capital movements, political stability plays a major role; but, perhaps, these have adequately been taken account of in the rate-of-interest calculations.

The paper by Borts and Kopecky is the only one on capital movements and economic growth. They construct a growth model to generate a country's equilibrium pattern of various aggregative variables including the return flows of interest and dividends earned abroad. International capital movements are independent of national differentials in interest rates and continue in a given direction with a uniform worldwide interest rate. They conclude, using regression analysis, that capital movements can be explained by means of a growth model without any reference to differential yields or to any monetary factors. This paper, I think, contains excellent comments by Tarshis and Balassa, and I recommend them highly to readers.

The remaining two papers, one by Salant and one by Laffer, deal with international financial intermediation. Salant concludes that financial intermediation by the United States accounted for a good part of its liquidity deficits in the 1950's and 1960's. Laffer found a one-to-one relationship between capital outflow and trade surplus; a positive relationship between capital outflow and increases in the American money supply; and a negative relationship between capital outflow and real growth, increases in exports, and the velocity of money in the United States. There is no empirical evidence that American deficits imply overdevaluation of the dollar. I find the comments to these papers, at least that by Modigliani, to be very good.

I highly recommend this book especially to people interested in the areas of international economics. However, it is not a textbook but a book which should be used to supplement student texts used in international monetary theory courses. Again, however, I would like to have seen some input by real world entrepreneurs since many of the topics covered largely deal with motivations of international firm managers. Also, as many authors pointed out, the data on direct investments are such that empirical analysis can support almost any hypothesis put forth concerning determinants of direct investment. I believe that, to do meaningful quantitative work in this area, one needs cross-section data on individual firms for specific industries. I am in agreement with Professor Caves who, in a separate paper, states that the theory of direct investment belongs more to the theory of industrial organization than it does to other bodies of economic theory and, thus, individual firm data are required.

Perhaps the most disturbing feature of this book is the lack of emphasis on the welfare effects of capital movements. A great deal of literature is available on the gains from international trade where one assumes that there are no international capital flows. Unfortunately, however, little work has been done on the welfare effects of international capital movements. For most countries, international capital flows are likely more important than trade in products. I suggest that another conference be held on the welfare effects of international capital movements.

Andrew Schmitz
University of California, Berkeley

Smith, Robert S., Frank T. de Vyver, and William R. Allen, eds., *Population Economics: Selected Essays of Joseph J. Spengler*, Durham, Duke University Press, 1972, v + 536 pp. ($17.50)

From more than 200 of Prof. Spengler's books and articles on economics, of which more than 100 deal with economic demography, the compilers have chosen 17 of his most profound works for this anthology. The essays selected were originally published from 1944 to 1966. Each represents the work of a mature and polished scholar, since Spengler's earliest publications date from 1929. Surprisingly little duplication is present among them, despite their concentration on an economic specialty that until now has not received the attention due it.

The anthology is divided into three parts. The first, "History of Thought," contains three essays on the economic and population theories of Malthus, Pareto, and Marshall, respectively. These chapters underline the validity of the well known aphorism (paraphrased) that those who fail to study the history of ideas are doomed to repeat the intellectual fallacies of the past.

The second part, called simply "Theory," explores the relationship between population magnitude and growth and economic advancement. The framework surrounding these writings is profoundly neo-Malthusian. Discussions of "limitational" factors in population and economic growth, of "maladjustments" from a population optimum, and of pronatalist policies are all rooted in a world view in which resources, if not fixed in the long run, are at least limited. Of course, to summarize thus 20 years of effort and more than 200 pages of carefully selected material has its obvious hazards, but I believe the summary to be an accurate one. The section ends with an essay entitled, "Was Malthus Right?" (published in 1966) in which Spengler asserts colorfully that "Unless the wings of the stork are clipped in the short Indian summer that lies ahead, at least one of the four horsemen, Hunger, will ride within the lifetime of our children" (p. 377).

The final section, called "Development," deals specifically with the relation between population growth and the economic development of low-income countries. The work is characterized by the same relentless style of the other essays. Long lists of factors that affect development appear, and their implications for population growth and vice versa are assessed.

It is instructive to follow the quite rapid evolution of Spengler's concern from "'present-day theories which treat the decline in population growth as an important check to economic activity and expansion" (p. 92, published in 1944) to the view that "population growth is a major obstacle to economic betterment in most parts of the world. It is retarding capital formation, accelerating the rate of depletion of the world's limited store of nonreplaceable resources, augmenting the rise of costs in increasing-cost industries, and decelerating the rate of increase of per capita income" (p. 447, published in 1951).

While some of the earlier papers, in my opinion, pay less attention than they should to the changes in the age distribution that accompany rapid population growth, this shortcoming was partly remedied in his presidential address to the American Economic Association in 1965. That speech also contained a plea for an economic approach to population control, since "'As matters stand, the longer-run prospect is definitely neo-Malthusian, with man sitting on a demographic time bomb into which legislators, and others, here and abroad, continue to shovel combustibles" (p. 353).

Whether the population problem is adequately analyzed by assessing the number of types of relatively augmentable and nonaugmentable factors, that is, by using a neo-Malthusian framework, depends on the time horizon in question. Those concepts do seem appropriate for the long-run, especially if pessimistic assumptions about the speed and direction of technological change are made. In the shorter run, the juvenilization of the population and the consequently increased demands for social services are likely to press public resources even more keenly, although no Malthusian overtones are attached to such changes.

Perhaps the most unusual theme, one not usually explored by demographers or economists, deals with the aesthetics of population growth. Spengler asserts that "undue population growth is currently tending to debase aesthetic values and to be fostered by such debasement" (p. 302, published in 1957). That work, contained in a presidential address to the Population Association of America, rises to the occasion by anticipating much of the research of the next decade that has asked, "Growth for what?" In addition, tantalizing glimpses of the child-as-durable-consumer-good are given in advance of later research on that subject.

In general, this is the sort of book to be read and savored on long, rainy winter afternoons. Because it provides neither recipes nor easy formulas, it is unlikely to appeal to persons seeking a demographic cookbook. The high degree of sophistication of the author and his unflinchingly lofty style do not permit skim-reading, much less skim-thinking.

Spengler favors the deductive method and the arithmetic example over fancier (and perhaps more easily misused) econometric hypothesis testing. This is probably just as well, since some significant fraction of his concern—that dealing with optimum population size—is simply incapable of empirical verification, however attractive the pure reasoning may be.

The essays were published at different dates, the most recent being 1966. To a certain extent, they mirror and anticipate the intellectual currents that swirl around them. Since this collection has not been published posthumously, its value would have been considerably enhanced by a retrospective overview by their author. Which of his own ideas does he now consider dated? Which ones have time and further research, by himself and others, left untarnished or even enhanced? Spengler's own assessment, in view of his evident scholarship and erudition, would have been helpful in this respect.

BRUCE HERRICK
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Books for listing in this section should be sent to the Book Review Editor (see inside front cover for address).

Books Received

Agrawal, R. C., and Earl O. Heady, *Operations Research Methods for Agricultural Decisions,* Ames, The Iowa State University Press, 1972, xi + 303 pp. $10.95.

Andrews, Stanley, *Agriculture and the Common Market,* Ames, The Iowa State University Press, 1973, xiii + 183 pp. $7.95.

Bahr, Howard M., Bruce A. Chadwick, Darwin L. Thomas, eds., *Population, Resources and The Future: Non-Malthusian Perspectives,* Provo, Brigham Young University Press, 1972, viii + 352 pp. $3.95. Paper.

Baker, Stanley, *Milk to Market: Forty Years of Milk Marketing,* London, William Heinemann Ltd., 1973, xiv + 282 pp. £3.90.

Barnard, C. S., and J. S. Nix, *Farm Planning and Control,* London, Cambridge University Press, 1973, viii + 549 pp. $22.50.

Bauer, P. T., *Dissent on Development: Studies and Debates in Development Economics,* Cambridge, Harvard University Press, 1972, 550 pp. $15.00.

Berg, Alan, *The Nutrition Factor: Its Role in National Development,* Washington, D.C., The Brookings Institution, 1973, xii + 290 pp. $8.95 Cloth, $3.50 Paper.

Berg, Alan, Nevin S. Scrimshaw, and David L. Call, eds., *Nutrition, National Development and Planning,* Cambridge, The MIT Press, 1973, xiii + 401 pp. $10.00.

Boulding, Kenneth E., and Martin Pfaff, eds., *Redistribution to the Rich and the Poor: The Grants Economics of Income Distribution,* Belmont, Wadsworth Publishing Company, Inc., 1972, ix + 390 pp. Price Unknown. Paper.

Brinkworth, B. J., *Solar Energy for Man,* New York, John Wiley & Sons, Inc., 1972, xii + 251 pp. $8.95.

Burnham, D. C., *Productivity Improvement,* New York, Columbia University Press, 1973, 73 pp. $4.95.

Center for Rural Manpower and Public Affairs, *Labor Market Information in Rural Areas,* Proceedings of a Conference, February 22-23, 1972, East Lansing, Michigan State University, viii + 239 pp. Price Unknown. Paper.

Center for Rural Manpower and Public Affairs, *Manpower Planning for Jobs in Rural America,* Proceedings of a Conference, December 14-15, 1972, East Lansing, Michigan State University, viii + 222 pp. Price Unknown. Paper.

Chase, Samuel B., Jr., ed., *Problems in Public Expenditure Analysis,* 4th ed., Washington, D.C., The Brookings Institution, 1968, xiv + 269 pp. $2.95. Paper.

Cheung, Steven N. S., *The Theory of Share Tenancy,* Chicago, The University of Chicago Press, 1969, xv + 188 pp. $9.50.

Clawson, Marion, ed., *Modernizing Urban Land Policy,* Papers presented at an RFF Forum held in Washington, D.C., 13–14 April, 1972, Baltimore, The Johns Hopkins University Press for Resources for the Future, Inc., 1973, vii + 248 pp. $11.00.

Cole, H. S. D., Christopher Freeman, Marie Jahoda, and K. L. R. Pavitt, eds., *Models of Doom: A Critique of the Limits to Growth,* New York, Universe Books, 1973, vi + 244 pp. $8.00 Cloth, $2.95 Paper.

Gorham, J. Richard, *Paraguay: Ecological Essays,* Miami, Academy of the Arts and Sciences of the Americas, 1973, xi + 296 pp. Price Unknown.

Haley, Charles W., and Lawrence D. Schall, *The Theory of Financial Decisions,* New York, McGraw-Hill Book Company, 1973, xviii + 383 pp. $11.95.

Hart, P. E., M. A. Utton, and G. Walshe, *Mergers and Concentration in British Industry,* London, Cambridge University Press, 1973, xii + 178 pp. $5.75. Paper.

Jones, J. G. W., ed., *The Biological Efficiency of Protein Production,* London, Cambridge University Press, 1973, xi + 385 pp. $21.00.

Kelley, Allen C., Jeffrey G. Williamson, and Russell J. Cheetham, *Dualistic Economic Development: Theory and History,* Chicago, The University of Chicago Press, 1972, xi + 399 pp. $12.50.

Kelso, Maurice M., William E. Martin, and Lawrence E. Mack, *Water Supplies and Economic Growth in an Arid Environment: An Arizona Case*

Study, Tucson, The University of Arizona Press, 1973, xviii + 327 pp. $8.50. Paper.

Knapp, Joseph G., *The Advance of American Cooperative Enterprise: 1920–1945,* Danville, The Interstate Printers & Publishers, Inc., 1973, xvii + 646 pp. $9.95.

Kramer, Amihud, and Bernard A. Twigg, eds., *Quality Control for the Food Industry,* 3rd ed., Vol. 2, Westport, The AVI Publishing Company, Inc., 1973, ix + 550 pp. $19.00.

Kuenne, Robert E., *Columbia Essays on Great Economists: Eugen von Böhm-Bawerk,* New York, Columbia University Press, 1971, ii + 76 pp. $1.45. Paper.

Maxwell, James A., *Financing State and Local Governments,* rev. ed., Washington, D.C., The Brookings Institution, 1969, xvii + 275 pp. $2.95. Paper.

Mechanic, David, *Public Expectations and Health Care: Essays on the Changing Organization of Health Services,* New York, John Wiley & Sons, Inc., 1972, x + 314 pp. Price Unknown.

Minhas, B. S., K. S. Parikh, and T. N. Srinivasan, *Scheduling the Operations of the Bhakra System: Studies in Technical and Economic Evaluation,* Calcutta, Statistical Publishing Society, 1972, xii + 89 pp. Price Unknown.

Nelson, Michael, *The Development of Tropical Lands: Policy Issues in Latin America,* Baltimore, The Johns Hopkins University Press for Resources for the Future, Inc., 1973, xvii + 306 pp. $12.50.

Nicholson, T. A. J., *Optimization in Industry: Optimization Techniques,* Vol. I, Chicago, Aldine · Atherton, 1971, xiii + 222 pp. $12.50.

Paik, C. M., *Quantitative Methods for Managerial Decisions,* New York, McGraw-Hill Book Company, Inc., 1973, xiii + 403 pp. Price Unknown.

Patel, Malvika, and James Esmay, *Price Theory Workbook,* Pacific Palisades, Goodyear Publishing Company, Inc., 1973, vi + 113 pp. $5.25. Paper.

Pereira, H. C., *Land Use and Water Resources: In Temperate and Tropical Climates,* Cambridge, Cambridge University Press, 1973, xiv + 246 pp. $14.95 Cloth, $5.95. Paper.

Psacharopoulos, George, *Returns to Education: An International Comparison,* San Francisco, Jossey-Bass Inc., 1973, xiii + 216 pp. $8.50.

Robinson, Romney, *Columbia Essays on Great Economists: Edward H. Chamberlin,* New York, Columbia University Press, 1971, ii + 70 pp. $1.45. Paper.

Rodriquez, J. G., ed., *Insect and Mite Nutrition: Significance and Implications in Ecology and Pest Management,* Amsterdam, North-Holland Publishing Company, 1972, xiii + 702 pp. $30.00.

Sharpe, Myron E., *John Kenneth Galbraith and the Lower Economics,* White Plains, International Arts and Sciences Press, Inc., 1973, xii + 86 pp. $6.00.

Smith, Al, Anthony Downs, and M. Leanne Lachman, *Achieving Effective Desegregation,* Lexington, D. C. Heath and Company, 1973, vii + 249 pp. Price Unknown.

Van Arsdel, Wallace B., Michael J. Copley, and Arthur I. Morgan, eds., *Food Dehydration: Drying Methods and Phenomena,* 2nd ed., Vol. I, Westport, The AVI Publishing Company, Inc., 1973, xi + 347 pp. Price Unknown.

Weitz, Raanan, ed., *Urbanization and the Developing Countries: Report on the Sixth Rehovot Conference,* New York, Praeger Publishers, 1973, x + 308 pp. $16.50.

Wolfson, Murray, *Columbia Essays on Great Economists: Karl Marx,* New York, Columbia University Press, 1971, ii + 68 pp. $1.45. Paper.

Woodroof, Jasper Guy, *Peanuts: Production, Processing, Products,* 2nd ed., Westport, The AVI Publishing Company, Inc., 1973, xi + 330 pp. $17.00.

Announcements

WINTER MEETING
AMERICAN AGRICULTURAL ECONOMICS ASSOCIATION
WITH THE
ALLIED SOCIAL SCIENCE ASSOCIATIONS

December 28–30, 1973
New York, New York

Factor Productivity in Agriculture

(Joint session with the Econometric Society)
December 29, 1973
10:30 A.M.

Chairman: T. D. Wallace, Department of Economics, North Carolina State University

Paper: "A Cost Function Approach to the Measurement of Factor Demand Elasticities and Elasticities of Substitution"
Hans Binswanger, Agricultural Development Council

Paper: "The Significance of the Green Revolution in Recent Development Experience"
Robert Evenson, Economic Growth Center, Yale University

Discussants: Jere Behrman, Department of Economics, The Pennsylvania State University; E. J. R. Booth, Department of Agricultural Economics, The University of Connecticut

Energy Supply and Demand in the United States

(Joint session with the American Economic Association)
December 29, 1973
2:00 P.M.

Chairman: Duane Chapman, Department of Agricultural Economics, Cornell University

Paper: "Incentive Policy and Supplies of Energy Sources"
Stephen L. McDonald, Department of Economics, University of Texas

Paper: "Policies for Energy Research and Development"
Harry Perry and Milton F. Searl, Resources for the Future

Paper: "Demand Studies for Energy Resources"
Hendrik Houthakker, Department of Economics, Harvard University, and Philip Verlege Data Resources, Inc.

Paper: "Supply-Demand Interactions: Environme tal Protection, Price Policy and Industrial Orga zation"
John Wilson, Federal Power Commission

Discussants: A. Myrick Freeman, Economics D partment, Bowdoin College; Richard L. Gordo Department of Mineral Economics, The Penns vania State University; Robert Kalter, Depa ment of Agricultural Economics, Cornell Univ sity; Walter Mead, Department of Economi University of California, Santa Barbara.

Policies for Agriculture: Food and Trade

(American Agricultural Economics Association)
December 28, 1973
2:00 P.M.

Chairman: Kenneth R. Farrell, Economic R search Service, USDA

Paper: "The World Food and Agriculture Situati in Perspective"
Don Paarlberg, USDA

Additional Papers: to be announced.

Discussants: to be announced.

CHANGE IN EDITORSHIP OF AJAE

For Volume 56 and beginning with the Februa 1974 issue, the new editorial staff of the *Americ Journal of Agricultural Economics* will be:

Co-Editors: Max R. Langham
Leo Polopolus
Associate Editors: Robert D. Emerson
Lester H. Myers

Peter G. Helmberger will continue as Book R view Editor.

BACK ISSUES NEEDED

Year	Volume	Issue
1919	1	1,2,3,4
1920	2	1,2,3,4
1921	3	1,2,3,4
1922	4	1,2,3,4
1923	5	1,2,3,4
1924	6	1,2,3,4
1925	7	1,2,3,4
1926	8	1,2,3,4
1927	9	3
1928	10	1
1935**	17	1
1940	22	1
1941	23	1
1942	24	2
1943	25	1,2,3,4
1944	26	2,3,4
1945	27	1,2,3,4
1946	28	1,2,3,4
1947	29	1,2,3,4
1948	30	1,2
1950	32	1
1951	33	1,2,3
1952	34	1,5
1953	35	1,5
1954	36	1,2,3,4
1955	37	1,2,3,4,5
1956	38	1,2,3,5
1957	39	1,2,3,4,5
1958	40	1,2,3
1959	41	1,3
1960	42	1,3,4,5
1961	43	1,2,3,4,5
1962	44	1,2,3
1963	45	1,2,3,4,5
1964	46	1,2,3,4,5
1965	47	1,3
1967	48	2
1968	49	1–1, 1–2
1970**	52	1

** Issues needed immediately—$2.00 per copy will be paid instead of $1.00. Journals should be sent prepaid to John C. Redman, Secretary-Treasurer, AAEA, Department of Agricultural Economics, Room 220 Agricultural Experiment Station, University of Kentucky, Lexington, Kentucky 40506.

NEW JOURNAL

Elseviers Applied Science Publishers Ltd. announces the publication of a new journal, *Agricultural Administration: An International Journal*. The first issue of this quarterly journal will be published in January 1974.

Agricultural Administration is edited by Professor A. M. Duckham and Dr. J. Pearce of the University of Reading, England, assisted by an Editorial Board of 16 international authorities. It will provide a high level critical, rather than "popular," forum for the interchange of experience in and ideas on agricultural administration between different countries, commodities, production systems, and social systems.

STUDENT REGIONAL STUDIES AWARDS PROGRAM

The Southern Regional Science Association announces an award for the best study submitted by a student on a subject within the scope of regional science. The author of the best study will be invited to present his or her paper at the annual meeting of the Southern Regional Science Association (SRSA) in Washington, D.C. on April 4–5, 1974. The author will also receive an honorarium of $100, and the study will be considered for publication in an issue of *The Review of Regional Studies*.

The following rules govern the competition:

1. The competition is open to undergraduate and graduate students (a) who are currently enrolled in an academic program or (b) who have completed degree requirements in the academic year 1973–1974.
2. All studies must be submitted to the Chairman of the SRSA Competition Committee and postmarked not later than February 1, 1974.
3. The submission should not have been previously submitted for publication in a professional journal. SRSA retains the right to the use, publication, and release of the submissions.
4. Each study should be not longer than 15 typewritten pages of text, double spaced. The study must be submitted in three copies. The study should be submitted in edited form, without corrections, and with due regard for the standard principles of format. Footnotes should be included at the end of the text.
5. The name of the author, his affiliation, and the title of the study should be on a separate cover sheet. The first text page should contain only the title of the study and the text. Each submission will be numbered, and the cover sheet will be removed before the study is reviewed.
6. The author of the winning study will be notified on or before March 10, 1974.

Communications and papers for consideration should be sent to the Chairman of the SRSA Competition Committee: ***James M. Stepp**, Department of Agricultural Economics, Clemson University, Clemson, South Carolina 29631.*

ECONOMIC RESEARCH SERVICE REORGANIZATION

The Economic Research Service (ERS) of the U. S. Department of Agriculture was reorganized during July 1973 with new priorities placed on commercial agriculture, consumer, and environmental quality issues. Issue-oriented, team research will be emphasized in this first agency-wide reorganization of ERS since it was formed 12 years ago.

Organizational changes are designed to produce more timely, more accurate, more sophisticated, and more up-to-date research information, according to ERS Administrator Quentin M. West. "Initially we intend to concentrate on the adjustments facing commercial agriculture, how well agriculture is providing for consumers' needs and the effect of agricultural operations on the environment," West said.

Greater flexibility in concentrating resources on new problems and issues is anticipated from the ERS changes, according to West. Organization barriers among divisions have been lowered to facilitate a team approach to issues that cut across entire subsectors of agriculture, such as the livestock industry or the grain industry. Cooperative relations with universities and agricultural experiment stations are being strengthened.

VISITING LECTURER PROGRAM

The American Agricultural Economics Association is again conducting a Visiting Lecturer program for 1973–74. The Visiting Lecturer program is limited to those universities offering an undergraduate or master's degree, but not a Ph.D. degree. Since Association funds are not available to support the program, attempts are made to match the desire for a particular individual to give a lecture with the availability of that person to travel to the university.

The procedure works best where the college or university selects three or four specific agricultural economists they would like to have visit their school. The chairman contacts the selected individuals to see if they are available to give the requested lecture. Generally, dates are negotiated directly between the lecturer and the school from that point.

The chairman would be very happy to receive requests. Send the requests to R. J. Hildreth, Farm Foundation, 600 South Michigan Avenue, Chicago, Illinois 60605.

News Notes

THE AGRICULTURAL DEVELOPMENT COUNCIL, INC.

Appointment: **C. Geoffrey Swenson,** Ph.D. Michigan State, as an associate. He will be stationed in Indonesia to work at the Agricultural University at Bogor in September 1973.

Reassignment: **Arthur T. Mosher** stepped down on June 1, 1973, as President of ADC, a position he held 16 years. He will remain with the Council as associate for Sri Lanka (Ceylon) and as a visiting professor in the Faculty of Agriculture, University of Sri Lanka, Peradeniya.

Retirement: **Herman M. Southworth,** after 6 years as an ADC associate in Korea. Prior to his departure from Korea, he was awarded an honorary doctorate of agriculture from Seoul National University.

THE UNIVERSITY OF ALBERTA

Appointment: **T. A. Petersen,** professor, as chairman of the Department of Agricultural Economics and Rural Sociology.

Return: **L. P. Apedaile,** associate professor, from a two-year appointment in Zambia.

THE UNIVERSITY OF ARIZONA

Appointments: **John Day,** Agricultural Planning Advisor in Turkey for one year; **Thomas Stubblefield,** one-third time assistant to the Experiment Station Director; **Reuben Weisz,** assistant agricultural economist.

Honors: **Clarence Edmond,** State Leader, and the Community Development Section, Agricultural Extension Service, have been awarded the Superior Service Award by USDA.

UNIVERSITY OF CALIFORNIA, DAVIS

Leaves: **Ben C. French,** sabbatic leave until June 30, 1974, to study and evaluate systems analysis and operations research methods in agricultural marketing, Washington, D.C.; **Refugio Rochin,** Department of Economics, with the Ford Foundation in Bogota, Colombia, as Program Assistant in Rural Development.

CLEMSON UNIVERSITY

Appointment: **Daniel B. Smith,** Ph.D. Kentucky, assistant professor.

CORNELL UNIVERSITY

Appointments: **David L. Call,** from H. E. Babcock Professor of Food Economics, to Director of Cooperative Extension; **Allen E. Lines,** research associate and Resident Director of the Cornell-Miner Project located at Chazy, New York; **Henry A. Wadsworth,** Associate Director of Cooperative Extension.

Leaves: **Joseph B. Bugliari,** six months leave for writing; **Olan D. Forker,** to ERS and Farmer Cooperative Service, USDA; **Kenneth L. Robinson,** one year to International Institute of Tropical Agriculture, Ibadan, Nigeria.

ECONOMIC RESEARCH SERVICE

(CED, Commodity Economics Division; FDCD, Foreign Demand and Competition Division; FDD, Foreign Development Divison; NEAD, National Economic Analysis Division; NRED, Natural Resource Economics Division.)

Appointments: **David P. Elliott,** Ph.D. Hawaii, NEAD; **Spencer F. England,** FDCD; **Steven Guebert,** Ph.D. Wisconsin, NEAD; **Linley E. Juers,** associate administrator, ERS, USDA, Washington, D.C., from deputy administrator; **Rodney C. Kite,** Ph.D. Purdue, NEAD; **Brian J. Pritchard,** FDCD; **Mark Schmitz,** completing Ph.D. North Carolina, NEAD Historical Division; **Rodney E. Steele,** FDCD; **Gary C. Taylor,** assistant deputy administrator, ERS, USDA, Washington, D.C., from the National Water Commission.

Awards: **Wayne D. Rasmussen,** leader of the Agricultural History Group, NEAD, USDA Distinguished Service Award; **Bill Bolton,** NEAD, USDA Superior Service Award.

Leave: **Francis S. Urban,** FDCD.

Reassignments: The newly reorganized ERS has **Quentin M. West** as administrator; **Linley E.**

Juers, associate administrator; and deputy administrator **Kenneth R. Farrell** heading the Food and Fiber Economics Group. Three divisions under his supervision include The National Economic Analysis Division headed by **William T. Manley**; The Commodity Economics Division, under **John E. Lee, Jr.**; and The Foreign Demand and Competition Division, directed by **Joseph W. Willett.** The other main group, Resource and Development Economics, is headed by deputy administrator **Lyle P. Schertz.** The two divisions under this group are The Foreign Development Division under **William A. Faught**; and The Natural Resource Economics Division directed by **Melvin L. Cotner.** The Division of Information is headed by **Wayne V. Dexter. Cecil W. Davison,** CED-Urbana, Illinois, to Washington, D.C.; **James R. Donald,** former acting director of the Economic and Statistical Analysis Division, to deputy director, NEAD; **Samuel Donald,** NEAD-Washington, D.C., to Southern University, Baton Rouge, Louisiana; **Wyatte L. Harman,** CED-Stillwater, Oklahoma, to Washington, D.C.; **Herbert R. Hinman,** CED, Farm Production Economics Division, USDA, to FDD, USDA, Washington, D.C.; **James Horsfield,** NRED-Providence, Rhode Island, to Upper Darby, Pennsylvania; **Frederick L. Hoff,** CED-Lexington, Kentucky, to Washington, D.C.; **George D. Irwin,** former head of the Southern Field Group, Farm Production Economics Division, ERS, has been named Program Leader, Structure and Adjustments in Food and Fiber Sector, NEAD, and remains headquartered at North Carolina State University; **Neil R. Martin,** CED-Urbana, Illinois, to Athens, Georgia; **Ronald Rhoade,** NRED-East Lansing, Michigan, to Berkeley, California; **Gordon Rodewald,** NEAD, completed a short term assignment for AID in Jordan; **Rodney L. Walker,** CED-Washington, D.C., to Lafayette, Indiana.

Retirements: **Wylie D. Goodsell,** CED; **Earl F. Hodges,** CED; **Trienah Meyers,** staff assistant to ERS Administrator; **Forest G. Warren,** CED.

UNIVERSITY OF FLORIDA

Appointment: **Wen-Shyong Chern,** Ph.D. California-Berkeley, research economist in the Florida Department of Citrus and assistant professor in the Department of Food and Resource Economics; **Richard Levins,** M.S. Florida, assistant professor and area assistant farm management specialist; **George O. Westberry,** M.S. Georgia, assistant professor and area assistant farm management specialist.

Reassignment: **Leo Polopolus,** professor and editor of *AJAE,* has been named chairman of the Department of Food and Resource Economics and coeditor of *AJAE.*

Resignation: **Marvin Konyha,** assistant professor, to accept a position as program leader, Manpower and Community Facilities, with the Community Resource Development Staff, Extension Service, USDA, Washington, D.C.

UNIVERSITY OF GUELPH

Appointments: **George L. Brinkman,** formerly with Kansas State University, associate professor in rural development; **Karl D. Meilke,** Ph.D. Minnesota, assistant professor in price analysis; **Wayne C. Pfeiffer,** formerly with the Ontario Ministry of Agriculture and Food, assistant professor in production economics; **Richard L. Trimble,** Ph.D. Michigan State, assistant professor in agricultural finance.

Resignation: **John C. Flinn,** associate professor, to ITTA, Ibadan, Nigeria.

Return: **Murray A. MacGregor,** professor, from one year leave of absence at the University of Edinburgh.

UNIVERSITY OF ILLINOIS

Appointment: **Thomas L. Frey,** associate professor.

Leave: **R. W. Herdt,** on leave with the International Rice Research Institute, Philippines, for one year ending July 31, 1974.

Return: **V. I. West,** from two years leave at Njala University College, Sierra Leone, West Africa.

INSTITUTO INTERAMERICANO DE CIENCIAS AGRICOLAS DE LA OEA

Appointments: (in recently initiated Hemispheric Marketing Program): **Michael J. Moran,** program coordinator; **Carlos Fletschner,** marketing specialist; **Norberto Frigerio,** marketing specialist; **Hugo Torres,** marketing specialist; **J. Pablo Torrealba,** marketing specialist.

IOWA STATE UNIVERSITY

Appointments: **Bruce R. Beattie,** formerly with the University of Kentucky, associate professor of economics; **Michael D. Boehlje,** formerly with Oklahoma State University, associate professor of economics; **Robert W. Crown,** assistant professor; **John J. Miller,** research associate.

Leaves: **Leo V. Mayer,** associate professor, continues on leave through June 30, 1974, to serve as senior staff economist with the President's Council of Economic Advisers, Washington, D.C.; **Richard C. Maxon,** associate professor, continues on leave through August 31, 1974, to serve as senior visiting lecturer, Department of Agricultural Economics, University of Ibadan, Nigeria, sponsored by the Rockefeller Foundation; **Hylke Van de Wetering,** associate professor, for two years beginning August 1, 1973, to serve as Chief-of-Party on the Iowa-Peru project in Lima, Peru.

RESIGNATION: **H. B. Howell,** professor in the Cooperative Extension Service, after 39 years of service.

UNIVERSITY OF KENTUCKY

APPOINTMENTS: **Larry D. Jones,** Ph.D. Purdue, assistant extension professor in consumer marketing; **Clyde F. Kiker,** Ph.D. Florida, assistant professor.

LEAVE: **Barry W. Bobst,** associate professor, to Khon Kaen, Thailand, with the Kentucky/AID team.

UNIVERSITY OF MASSACHUSETTS

APPOINTMENTS: **Jon M. Conrad,** assistant professor; **Barry C. Field,** assistant professor.

AWARD: **Bradford Dean Crossmon** received the Distinguished Member Award from the Northeastern Agricultural Economics Council in recognition of his 36 years of "continuous devoted service to Northeastern agriculture."

RETIREMENT: **Sargent Russell,** professor, after 28 years of service.

MICHIGAN STATE UNIVERSITY

APPOINTMENTS: **Darrell Fineup,** professor, for two years; **Eckart Guth,** post doctoral study; **Peter Reider,** visiting professor, for one year.

LEAVE: **Dale Hathaway,** leave extended for one year.

RESIGNATION: **Dale Hathaway,** as Department Chairman.

MISSISSIPPI STATE UNIVERSITY

APPOINTMENT: **David W. Parvin, Jr.,** formerly with the University of Georgia at Experiment, associate professor in farm management-production economics.

THE UNIVERSITY OF NEBRASKA

APPOINTMENT: **Duane Olsen,** Ph.D. Missouri, associate professor in resource development.

OHIO STATE UNIVERSITY

RETIREMENT: **Clarence C. Bowen,** associate professor, after 26 years of service.

OREGON STATE UNIVERSITY

APPOINTMENTS: **Ludwig M. Eisgruber,** professor and head of the Department of Agricultural Economics; **Sheng Hui Liao,** research associate; **Stanley F. Miller,** associate professor and director, OSU/AID Weed Control Project.

LEAVES: **Clinton B. Reeder,** assistant professor and extension marketing/management specialist, one year sabbatical beginning October 1, 1973; **Russell C. Youmans,** associate professor and extension resource economist, one year sabbatical to Indiana University and India, beginning September 1, 1973.

RETIREMENT: **Marion D. Thomas,** professor and extension economist, after 35 years of service.

UNIVERSITY OF RHODE ISLAND

APPOINTMENT: **Ronald G. Cummings,** formerly with Resources for the Future, Inc., in Mexico, as professor and chairman, Department of Resource Economics.

STATISTICAL REPORTING SERVICE

(ED, Estimates Division; OA, Office of Administrator; RD, Research Divison; SD, Survey Division; SSO, State Statistical Office.)

HONORS: **Emmett B. Hannawald,** ED, USDA Superior Service Award; **Harold F. Huddleston,** RD, USDA Superior Service Award.

REASSIGNMENT: **James R. Garrett,** Indiana SSO to ED-Washington, D.C.

RETIREMENTS: **Gordon G. Butler,** ED; **Emmett B. Hannawald,** ED; **Coyle M. Whitworth,** South Carolina SSO.

UTAH STATE UNIVERSITY

HONOR: **E. Boyd Wennergren,** economist, received the Order of the Condor of the Andes, the highest civilian award given by the Bolivian Government, for humanitarian and professional assistance of a continuous nature to the people of Bolivia.

REASSIGNMENT: **Morris Whitaker** will be with the Utah State University/AID program in Bolivia.

RETURN: **Lloyd Clement,** after a three year assignment in Bolivia.

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

APPOINTMENTS: **Sandra S. Batie,** Ph.D. Oregon State, assistant professor; **George L. Greaser,** instructor.

RESIGNATION: **David L. Holder,** assistant professor, to Farmer Cooperative Service, USDA.

WASHINGTON STATE UNIVERSITY

APPOINTMENTS: **David W. Holland,** formerly with the University of Kentucky, assistant professor; **Walter Miklius,** director of the Economic Research Center at the University of Hawaii, visiting professor for one year.

LEAVE: **Leroy L. Blakeslee,** for one and one-half year assignment with Iowa State/AID program in Thailand.

WEST VIRGINIA UNIVERSITY

RETURN: **Ernest J. Nesius,** from two years in Vietnam as employee of the Foreign Development Division of USDA but under the direction of USAID. He directed the Agency's program of agricultural economics assistance to the Vietnamese agricultural leadership. He has been appointed Benedum Professor of Agricultural Economics.

UNIVERSITY OF WISCONSIN

APPOINTMENTS: **Richard C. Bishop,** assistant professor of natural resources; **Gerald R. Campbell,** assistant professor of commercial agriculture/marketing; **Sydney D. Staniforth,** director of the Recreation Resources Center; **Bruce Weber,** project associate at the Institute for Environmental Studies.

LEAVE: **Daniel W. Bromley,** for one year as economist with the Economic Analysis Group in the Office of the Secretary, U. S. Department of Interior, Washington, D.C.

OTHER APPOINTMENTS

Scott Adelsbach, M.S. California, Davis, assistant agricultural economist, California State Department of Agriculture, Sacramento.

Malcolm D. Bale, Ph.D. Wisconsin, assistant professor, Montana State University.

Wayne A. Boutwell, Ph.D. Virginia Polytechnic Institute and State University, to Commodity Economics Division, ERS, USDA.

Guy Brady, Jr., M.S. Arkansas, for a three month tour with the U. S. Army, then to Goodpasture, Inc., Grain Brokers, Houston, Texas.

Bayford D. Butler, M.S. California, Davis, to Federal Intermediate Credit Bank of Berkeley, 2120 Milvia Street, Berkeley.

Mario Chacon, M.S. California, Davis, to A.V. Universidad 1900 Ed., 8–403, Mexico 20 D.F.

Donald Chafin, Ph.D. Ohio State, to the Northern Trust Company, Chicago, Illinois.

Don Wayne Collinsworth, M.S. California, Davis, economist, Department of Fish and Game, State of California—Resources Agency, 1416 Ninth St., Sacramento, California.

Vincenzo Cosentino, M.S. California, Davis, to Centro Di Specializzazione E Ricerche Economico-Agrarie Per Il Mezzogiorno, 80055 Portici, Napoli, Italy.

Al Dyer, Ph.D. Utah State, Department of Forest Science, Colorado State University.

Roberto Fanfani, M.S. California, Davis, to Centro Di Specializzazione E Ricerche Economico-Agrarie Per Il Mezzogiorno, 80055 Portici, Napoli, Italy.

Donald Gailey, Michigan State, trainee, Commercial Lending Division (Agriculture), First National Bank, Dallas, Texas.

John Keith, Ph.D. Utah State, Utah Water Research Lab, Utah State University.

Yi-chuang Kuo, M.S. California, Davis, Research Institute of Agricultural Economics, Chung-Hsing University, Taichung, Taiwan, ROC.

Richard E. Maxwell, M.S. Arkansas, to Wellens & Co., Inc., Animal Feed Brokers, 6700 France Avenue South, Minneapolis, Minnesota.

Roger D. Montgomery, Ph.D. Cornell, to West Africa as contract professor of economics for University of Michigan.

Terry A. Moore, M.S. Florida, to enter law school at the University of Florida.

Larry C. Morgan, Ph.D. Kentucky, assistant professor, University of Tennessee.

Gerald Nehman, Ph.D. Ohio State, to the Battelle Memorial Institute, Columbus, Ohio.

Norman E. Payne, Ph.D. Cornell, to the Farm Credit Banks of Springfield at Springfield, Massachusetts.

Iby Pedroso, Ph.D. Ohio State, to Ministry of Agriculture, Brazilia, Brazil.

Hormoz Saleh, Ph.D. Cornell, returned to Iran and is privately engaged in developing beef and sheep production.

Yony Sampaio, M.S. California, Davis, to Graduate School of Economics, Universidade Federal De Pernambuco Engenho Do Meio, 50,000 Recife—Pernambuco, Brazil.

Blas Santos, M.S. California, Davis, to Catholic University Madre y Maestra, Santiago, Dominican Republic.

John Schamper, Ph.D. Wisconsin, research associate in dairy marketing, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul.

Narendra P. Sharma, Ph.D. Virginia Polytechnic Institute and State University, to International Bank for Reconstruction and Development.

Nureddin Taqieddin, Ph.D. Utah State, to the Jordan Valley Commission, Aman, Jordan.

Bruce C. Thompson, M.S. Wisconsin, agricultural statistician, Statistical Reporting Service, USDA, Madison, Wisconsin.

Ratna D. Wahab, M.S. Wisconsin, agricultural engineer, Bureau of Agricultural Economics, Jakarta, Indonesia.

J. Keith Wilkinson, Ph.D. Kentucky, Agricultural Division, Statistics Canada.

Tom Williams, Ph.D. Utah State, Division of Business and Economics, Southern Utah State University.

OBITUARIES

John Harvey Bondurant, 72, professor at the University of Kentucky for more than 40 years, died April 16, 1973, as a result of an accident at his home in Lexington, Kentucky.

A Kentucky native, Bondurant earned his B.S. at the University of Kentucky and M.S. and Ph.D. degrees at Cornell University. He was a member of the University of Kentucky Agricultural Economics faculty from 1932 until his retirement in 1971. After 1971 he continued his research at the University and many of his public service activities.

His major contributions included teaching land economics, farming systems, and land appraisal, and serving on state committees for land zoning and taxation. He was a project manager for the U. S. Resettlement Administration, which procured thousands of acres of land, much of which is now in Kentucky state parks. He pioneered in the organization of the Kentucky Association of Farm Managers and Rural Appraisers and served as secretary-treasurer from its inception in 1949 until his death; he was named appraiser of the year in 1949. He was an AID adviser to the Joint Commission of Rural Reconstruction, Republic of China, in the Taiwan land reform program; the Kentucky representative for USDA annual cost and return studies of commercial family farms; and member of numerous professional societies including the American Agricultural Economics Association, International Association of Agricultural Economists, Alpha Zeta, and Gamma Sigma Delta.

John H. Bragg suffered a fatal heart attack November 3, 1972, in Ibadan, Nigeria. He had been a faculty member of the Department of Agricultural and Food Economics at the University of Massachusetts since 1955.

Bragg received a B.S. and M.S. from the University of Maine and a D.B.A. from Indiana University. He taught management courses at the University of Massachusetts and was working with a team of specialists on a USAID project in Nigeria when stricken at the University of Ife in Ibadan. He is survived by his wife Phyllis, two daughters, Elizabeth and Judith, and son John.

William T. Butz, professor of agricultural economics at The Pennsylvania State University, died November 8, 1972.

He had been a member of the faculty since 1951. He was both a dedicated teacher and active researcher on the operational efficiency problems in dairy plants. Although his principal interest was dairy marketing, he also conducted several studies on processing efficiency and marketing of mushrooms. He co-authored a text on international understanding, and for a number of years he and the co-authors taught a course based on the text. Both course and text were pioneering efforts.

His interest in students is reflected in the active role he played in initiating several new student programs. He was instrumental in the organization of the Association's student debating contests and in coaching Penn State's teams. He also organized a departmental internship program which permitted students to obtain credit for supervised work in government and business positions. Because of his reputation for thoroughness and fairness and his skill as a mediator, he was repeatedly selected for the chairmanship of departmental committees and elected to the University Senate. Memorial gifts in his honor are being accepted by the Penn State Alumni Association.

Walter H. Ebling, 81, retired State Statistician for Wisconsin, died May 2, 1973, after a brief illness.

After teaching in Wisconsin rural schools from 1911 to 1917 and serving in World War I, Ebling served as assistant to H. L. Russel, Dean of Wisconsin's College of Agriculture until 1926. In 1929 he earned his doctorate and started his career with USDA's Crop and Livestock Estimates Service, where he worked until 1960. Ebling's main concern was to collect information from farmers and interpret the meaning in precise and lively reports. He also pioneered the first county farm bulletin, an idea now adopted by many other states. Long interested in young people, he prepared material for vocational agricultural teachers to acquaint farm youth with the agricultural facts of their localities. In 1951 Ebling was the first data specialist to win USDA's Distinguished Service Award for managing his office so well that it became an integral and vital part of Wisconsin's rural economy.

H. Brooks James, former president of the American Agricultural Economics Association, died on March 24, 1973. Born in North Carolina in 1912, he received the B.S. and M.S. degrees from North Carolina State University and the Ph.D. degree from Duke University. He did post-doctoral work at the University of Chicago.

Following graduation in 1932, Brooks James managed a farm, taught vocational agriculture, and served as a county agent and Extension farm management specialist. He was appointed to the NCSU faculty in 1944 and became head of the Department of Agricultural Economics in 1950. In that capacity, he presided over the Department in its period of greatest growth. As Director of Instruction in the School of Agriculture and Life Sciences, he led the modernization of the undergraduate programs of the School. He became Dean of the School in 1960 and was appointed Vice-President for Research and Public Service of the

Consolidated University of North Carolina in 1970, a position he held until his death.

Brooks James had a deep interest in economic development and had numerous overseas assignments for the U.S. government. He was a superb administrator, a man of ideas and vision whose constant goal was a better life for all mankind.

C. Delmar Kearl, 55, professor of farm management at Cornell University, died suddenly on June 27, 1973.

Born in Provo, Utah, Kearl received the B.S. degree from Utah State University and served four years in the U. S. Army. He received the M.S. and Ph.D. degrees from Cornell and joined its faculty as an assistant professor in 1949. He was promoted to associate professor in 1952 and to professor in 1961.

During his professional career, Kearl specialized in farm management. He taught a course in cost accounting, but spent most of his time and energy undertaking research on farm enterprise costs and returns and on evaluating new technology. He made his research available through a series of annual publications and took part in extension programs with farmers and others. Kearl was a competent, energetic, and forceful faculty member who researched his subject before arriving at conclusions which he was willing and able to defend, whatever the challenge or whoever the challenger.

Beginning in 1954, Kearl and his family spent two years at the University of the Philippines and assisted in development of the Department of Agricultural Economics. He interested many young Filipinos in the study of agricultural economics and had much influence in the early progress of a department which now offers the Ph.D. degree. While in the Philippines, he took a leading role in organizing the Philippine Agricultural Economics Association. In 1960 he served in Uganda as adviser to the Department of Agriculture.

He served with distinction as Secretary-Treasurer of the American Agricultural Economics Association from 1958 to 1969. He not only performed the work of that office with efficiency during a period of rapid growth of the Association, but assumed primary responsibility for preparing and publishing the first two directories of the Association's membership.

He is survived by his wife Marjorie; three daughters, Mrs. Sandra Kearl Stone, Debra Ann, and Shary Lynn; three sons, Steven, Kenneth, and Rodney; and a sister and four brothers.

Arnold Bendik Larson, 49, professor at the University of Hawaii, died on March 24, 1973, after an extended illness.

Born on a farm near Sandstone, Minnesota, he was educated there through secondary school, then attended the University of Minnesota. His undergraduate education was interrupted by four years of service in the U. S. Navy during World War II. He returned to graduate from the University of Minnesota in 1949, then earned his M.A. degree in 1951. Larson was on the staff at Colorado State University for one year and spent four years with the U. S. Bureau of Reclamation in Colorado and California. He next went to the Food Research Institute at Stanford University, where he earned the Ph.D. degree in 1960. He spent three years on the Stanford faculty before moving to the University of Hawaii, where he was promoted to professor in 1969. A sabbatical semester was spent at Stanford in 1970.

Larson published several works in price analysis and was known for his exceptional competence in statistics and econometrics. He was instrumental in building a strong graduate program at the University of Hawaii.

He lived in Kailua, Hawaii, where he is survived by his wife Jane and their sons, Lars and Iver.

World Food Production, Demand, and Trade

Leroy L. Blakeslee, Earl O. Heady, and Charles F. Framingham

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